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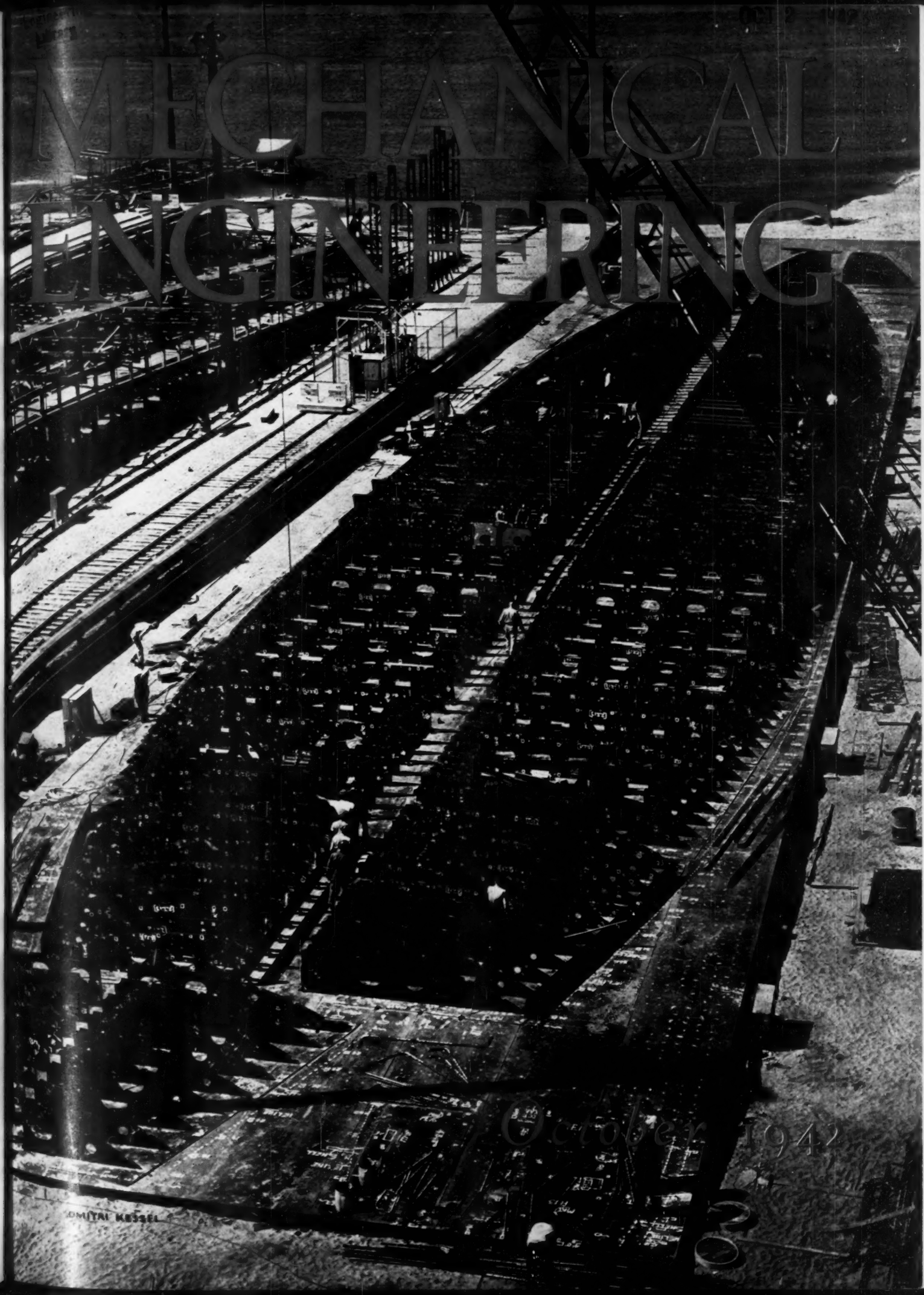

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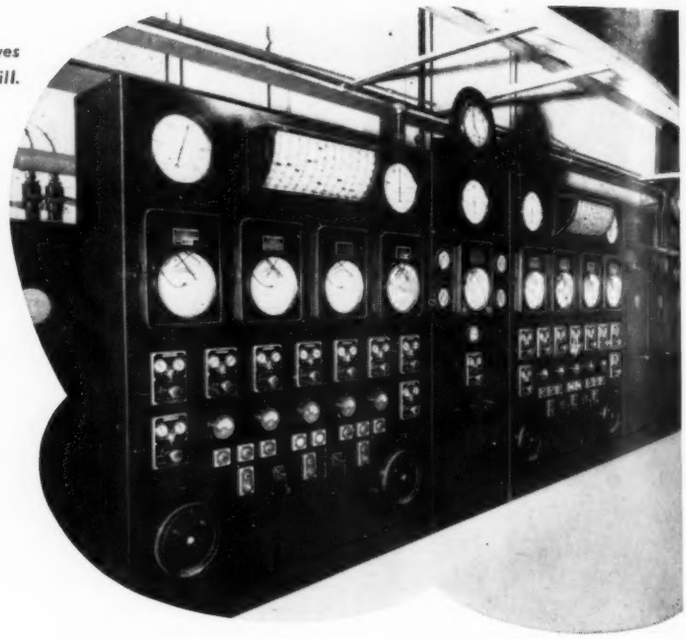

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MECHANICAL ENGINEERING

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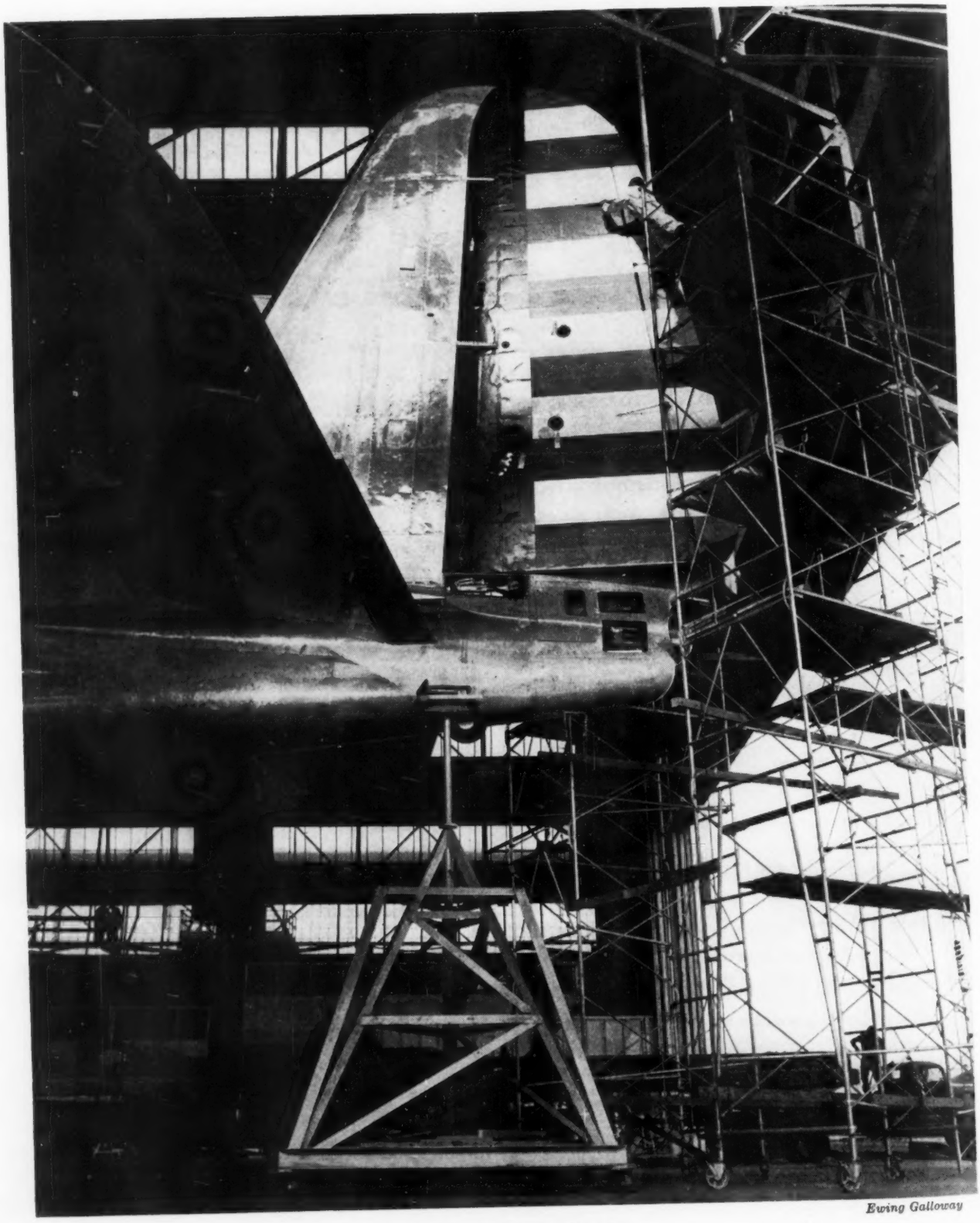

Ewing Galloway

The Tail of the Bomber

VOLUME 64
No. 10

MECHANICAL ENGINEERING

OCTOBER
1942

GEORGE A. STETSON, *Editor*

Covers

FOR many years MECHANICAL ENGINEERING has used pictorial covers by means of which a uniformity is achieved with a sufficient diversity of appearance to make each issue different and fairly distinctive. To pick out suitable photographs for these covers is an interesting and not too simple task. As the final results are bound to show, a number of technical points must be borne in mind, otherwise the cover lacks contrast and life, or becomes confused because of too much detail or poor composition. Naturally, some attention must be given to the suitability of the subject matter. The picture should suggest the mechanical engineer and his work or interests. Unfortunately, photographs that make excellent illustrations for technical articles are seldom adaptable for cover pictures. Hence there is a tendency to choose on the basis of composition, shape, contrast, design, or even symbolism, with the result that many pictures have little specific significance. In a majority of cases the reader is quite as competent as the photographer or the editor to identify the picture and hence only rarely is a picture named on the contents page. Obviously, the picture shows a steel mill, a machinist at a lathe, a power-plant sky line, or a locomotive, or some equally well-known subject that is suggestive of the mechanical engineer's interests and environment. To identify it specifically is frequently as impossible as it is unnecessary.

Another purpose in view in choosing cover pictures is to call attention to some A.S.M.E. meeting, which is further emphasized by an announcement of the meeting place and date at the bottom of the picture. For example, the September issue carried a cover which showed a number of lenses and prisms of optical glass made by the Bausch and Lomb Optical Company of Rochester, where the 1942 A.S.M.E. Fall Meeting is to be held. In taking the picture the photographer achieved an unusual design effect, quite different from the usual cover illustration, that was significant of one of Rochester's important industries and of one of the innumerable fields in which mechanical engineers are engaged. Hence it was appropriate from many points of view. Through an oversight a number of copies of the issue were printed without credit on the contents page to the Bausch and Lomb Optical Company. When this omission was discovered the presses were stopped and the omission was rectified in the remaining copies. Regrettable as this omission was it has provided an opportunity to say something about our covers, of which we are justifiably proud, to make amends to the company that provided the illustration, and to explain why so few covers are specifically identified on the contents page.

Perhaps readers are sufficiently curious to wish all cover illustrations identified. If so, an attempt will be made to be more specific, although in many cases this is difficult.

Surface Finish

WITH every machine tool in the nation doing its bit for the war effort the urgency of finding some means by which surface finishes can be classified, specified, and measured has inevitably increased. A manufacturer who controls every step in production from design to final assembly and inspection can probably determine within his own organization what quality of finish shall be maintained on every surface of every piece that makes up the final assembly, but even in a self-contained plant where several departments and many workers are to be found there will be differences of opinion when the words used to describe what is desired cannot be defined in quantitative terms. Subcontracting intensifies the normal difficulties experienced in maintaining full understanding of what is desired in the design, production, and inspection departments of a manufacturing project, and the lack of an adequate and commonly recognized "yardstick" of measurement gives rise to arguments and needless waste of time, material, and production capacity. Hence, anything bearing on the subject of surface finish is of great interest and importance.

Two papers in this issue are directed to the subject of surface finishes. Mary R. Norton, metallurgist, Watertown Arsenal, writes on "Development of Standards for Army Ordnance Finishes," and R. W. Dayton and H. R. Nelson, of Battelle Memorial Institute, with L. H. Milligan, of the Norton Company, report on researches in "Surface Finishes of Journals." Both papers contain references to the rather limited literature on the subject.

An effort on the part of The American Society of Mechanical Engineers to initiate a standardization project in the field of surface quality grew out of a paper presented at the 1930 A.S.M.E. Annual Meeting by R. E. W. Harrison in which it was suggested that a national standard of surface finishes be set up. A recommendation to the American Standards Association resulted in the organization of Sectional Committee (B46) for the Standardization of Classification and Designation of Surface Qualities under the sponsorship of the A.S.M.E. and the S.A.E. This committee prepared a Proposed American Standard of Surface Roughness, the most recent draft of which was issued in March, 1940.

In the meantime several instruments and techniques for measuring surface quality were developed in this country, in England, on the Continent, and elsewhere, and much work was done in laboratory and shop in this field by independent workers and by organizations concerned primarily with production as well as those engaged in the manufacture of machine tools and instruments. The most extensive of recent reports on the subject of surface finish was issued early in 1942 by the Institution of Production Engineers (Great Britain). This report, which was reviewed in the July issue of MECHANICAL ENGINEERING, is based on an eighteen-month investigation covering the values of 436 finished surfaces. It was edited by Dr. Geo. Schlesinger, director of Research Department, Institution of Production Engineers, who is also a member of A.S.M.E.

Quick to realize the value of the I.P.E. report and to make it easily available to engineers in this country, the A.S.M.E. secured permission to publish an American edition of it, which is now ready for distribution.

Publications in Wartime

WITH a few exceptions, papers published by The American Society of Mechanical Engineers have been or are to be presented at meetings and come to the Committee on Publications with the recommendation of the professional division or committee in whose field of interest their subject matter lies. The divisions and committees are responsible for the accuracy and technical quality of the papers they recommend. Reviewers, who may or may not be members of the committees, read the manuscripts submitted by the authors. They may suggest changes, additions, or deletions, condensation, or complete rewriting. They may reject the paper.

When the paper is accepted by the division or committee it is sent to the Committee on Publications with a recommendation that it be printed or that it be presented without being printed. On the basis of reviewers' comments and the recommendation, the Committee on Publications must decide whether or not to print the paper. Occasionally, the Committee on Publications gets an independent reviewer's opinion on the paper. It may suggest further revisions and condensation or rewriting. It may be forced by lack of funds to decide against publication. Because of its limited budget the Committee cannot always publish every paper recommended to it by the divisions and committees. These, briefly, are the normal procedures of peacetime by which the Society performs its function of disseminating information within its field for the benefit of its members.

In wartime there are additional matters to consider. With all-out war effort the published work of engineers must be given careful consideration. Preference must be given to papers that are most directly related to the war effort so that useful information and techniques may have wide and prompt circulation. The program-making groups, the divisions and committees, make up their programs with the needs of engineers engaged in war work in mind. The Society thereby provides forums in which valuable information can be broadcast and engineering problems discussed. Publication widens the usefulness of these forums by making the papers available to all.

But in spite of the desirability in wartime of giving as much assistance as is possible to engineers engaged in war work, much of this information cannot be made public, and that which is made public must be scrutinized by persons in authority to make sure that the best interests of the nation are safeguarded. Information likely to be useful to saboteurs must be suppressed and many technical papers that reveal new and secret processes must be ruled out. It is not always possible for an author or a publisher to decide what should and what should not be made public and hence the safest course to follow, when doubt arises, is to submit the proposed paper to the War Department, or other appropriate agency, and have it officially released for publication. Authors of papers can expedite publication and avoid last-minute refusal to present or publish their papers by finding out before programs are made up and before preprint or publication is considered whether or not their papers may be printed and securing the proper release.

Ever since last April a second hurdle has been placed in the way of technical publications. An export license must be obtained from the Board of Economic Warfare before technical periodicals can be mailed outside the country. Because technical papers have been released for publication in this country does not guarantee that the magazines in which they appear will be granted an export license. Although the Board of Economic Warfare does not wish to restrict the dissemination of technical information that may be useful to engineers in the Allied Nations or in the neutral nations, it must guard against the chance that the enemy may be aided by it to our harm. License to export may therefore be refused unless the material objected to is removed from the magazine.

In its publication procedure The American Society of Mechanical Engineers tries its best to live up to the spirit of wartime censorship. In doubtful cases release by some proper agency is secured, even if publication has to be delayed. News items, even reports of meetings from local sections that sometimes contain production or capacity data, are checked. Similar safeguards are exercised in connection with advertising.

Prelude to Planning

THE prelude to planning is the conditioning of the mind of the individual as to objectives to be attained, methods to be used, and the effects to be expected. Unless a sufficient number of intelligent persons expend the necessary time and mental effort to study objectives, methods, and effects, planning for the future is likely to be controlled by the few that have something to offer and a means of propaganda by which their views are woven into the fabric of public policy and opinion. An engineer's views on "The World We Want" will be found in this issue. Other engineers may not share Mr. Wyer's views, but they should be stimulated in reading them to clarify their own thoughts.

MEETING WARTIME FUEL PROBLEMS

By OLLISON CRAIG

ENGINEERING MANAGER, RILEY STOKER CORPORATION, WORCESTER, MASS.

THERE are few plants in this country that will not encounter some form of fuel problem because of conditions which arise from the present war. These problems are of great variety but come about mostly through location of the plant, kind of fuel burned, means of transportation, storing and handling of fuel, methods of firing, and demands for increased capacity.

The major fuels are coal, oil, and gas. Other fuels are coke, wood refuse, refinery refuse, blast-furnace gas, coke-oven gas, and a number of forms of refuse occurring in small quantities.

The fuel that an individual plant uses, or will use, depends upon its location, comparative cost of available fuels, and whether refuse fuel is obtainable. Plants located in the Southwest and on the Pacific coast have used oil and natural gas as principal fuels. North Central states and Atlantic coast states have mostly burned coal. Along the Atlantic coast, for some distance inland, oil is burned in considerable amounts. This is also true in those regions bordering the coal and oil areas. In these last areas more coal is burned when coal is the cheaper fuel, and more oil is burned when oil is cheaper.

Fuel problems will probably be greatest in those areas where coal is the principal fuel. This discussion will be largely confined to coal-burning plants, since the problems facing oil- and gas-burning plants are less complex and mainly occur because of the ability, or lack of ability, to obtain fuel. Refuse fuels, such as those referred to, will not be discussed since their use is greatly limited. It is to be expected that most coal-burning plants will be required to use coal of a lower grade than customary and will face the necessity of storing more coal than usual, since transportation will be limited and more irregular, and deliveries will not be made at fixed intervals as coal is used. Also, it appears very probable that the Government might allocate fuel and tell each plant just what kind and how much it can have. This will mean that many plants will be required to operate with fuel inferior to that previously used and at the same time obtain equal or even greater steam capacity than formerly.

It is the purpose of this paper to discuss some of the problems arising from the transportation and use of lower-grade coals and to indicate solutions to these problems.

AMPLE STORAGE SPACE SHOULD BE AVAILABLE

Protection against plant shutdown makes coal storage advisable. Use of transportation facilities for other and more critical needs will mean that the plant cannot get coal just when it is wanted. Unless a storage pile is available, a plant shutdown is a possibility. This presents the first problem, that of storage.

Space must be made available for sufficient volume of storage. Some plants have no such space and may have an insurmountable problem on this account. If, however, coal can be stored, it should be done in such a manner that it will not deteriorate or ignite. Midwestern coals ignite more readily by spontaneous combustion when stored in a pile than do most eastern coals. Such coals require greater care in storage. Coal can only ignite and burn in the presence of oxygen. To prevent ignition, it is necessary to prevent oxygen being supplied to the coal in a pile in sufficient quantities and at such a rate as to promote combustion. If air can penetrate a pile of coal, oxidation will occur at some rate which is a function of the temperature of the coal and the air. If the temperature rises as a result of this oxidation, the rate increases, the rise in temperature is accelerated until fire occurs. If, however, the rate of supply of oxygen is so low and the dissipation of heat is equal to the heat generated, so that no rise in temperature occurs, then the coal will not fire, although there will be some deterioration in the coal. This deterioration appears as less heat value of the coal by an amount that combustible matter has become oxidized.

PREVENTING FIRES IN COAL STORAGE PILES

The way to prevent firing of coal in storage piles is to exclude air. To accomplish this, coal should be laid down in uniform layers in such manner that there is no segregation of coarse and fines. It is desirable to pack each layer so that the greatest possible density is had in the pile. Thorough mixing of coal sizes, together with packing, reduces voids through which air can pass. The edges of the piles should be sloped for drainage and sealed. Fines, well packed on the slopes, provide a very good seal against admission of air to the interior of the pile. A covering of larger-size coal should then be laid over this packed surface to prevent erosion.

If heating occurs in the pile, it will be evidenced by vapor passing off the surface. This may be stopped by more careful sealing. If heating continues, it then becomes necessary to so move the pile that the heated portions can be cooled. Storage piles have fired due to the action of wind causing air penetration. Such action has been retarded or stopped by the erection of windbreaks.

Coal is burned under power boilers either on hand-fired grates, on stokers, or in pulverized form. This discussion will consider only the problems in connection with stoker firing and pulverized-coal firing.

FACTORS RELATING TO STOKER FIRING

If coal is fired on stokers, it may be necessary to increase the stoker area in order to get an equal or increased capacity with a lower-grade coal. In the case of chain-grate or traveling-grate stokers, this can be done by increasing the stoker length, which of course involves increasing the length of the furnace and additional expense for furnace construction. The area of multiple-retort underfeed stokers can be increased either in width or in length. The width can be increased by adding additional retorts at the sides. This may involve some furnace reconstruction. However, in many cases, the stoker width is less than the boiler width, the difference in width being taken up by corbeling. Frequently, in such cases the difference in these widths is

For presentation at the Sixth Annual Meeting of the Fuels Division of THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS, and the Coal Division of the American Institute of Mining and Metallurgical Engineers, St. Louis, Mo., Sept. 30–Oct. 1, 1942.

about equal to the width of an additional retort. This simplifies obtaining the extra stoker width and reduces the expense of installation. Most multiple-retort underfeed stokers are of such construction that additional underfeed or overfeed areas can be added in whatever proportion is desired. The furnace length will need to be changed to accommodate this increased stoker length.

In the case of multiple-retort underfeed stokers, changing from an intermittent-dump arrangement to a continuous ash discharge or clinker grinder is equivalent to lengthening the stoker, since the area over which coal can be burned as a live fuel bed is increased.

The coal-burning capacity of single-retort stokers cannot be increased much by increasing the furnace width, since no additional retort can be added, and the retort installed has a fixed width. Something can be accomplished, however, by increasing the length of the side grates, although the effective burning rate over these grates is less than over the retort. If the single-retort stoker is of the sectional-retort type, it then becomes quite simple to increase the length of the stoker by adding a section between the two ends.

The coal which may be received may limit capacities that can be carried with a given boiler and fuel-burning equipment, because of the temperature at which the ash fuses and clinkers. If ash clinkers in the fuel bed of the stoker, the clinkers tend to make the fuel bed more impervious to the passage of air and prevent air from coming into contact with the burning coal. The remedy for this condition is to provide means whereby the fuel bed can see more metal surface containing water. The more heat that can be radiated from the fuel bed to water tubes, the lower will be the temperature in the fuel bed and the greater the rate at which coal can be burned without producing troublesome clinkers.

A means of providing more exposure of water-tube surface to the fuel bed is to so change the shape of the bridge wall that more of the length of the first row of boiler tubes is exposed. This is particularly applicable to a large number of the old installations of straight-tube boilers fired with multiple-retort underfeed stokers. These installations usually had the bridge wall so arranged that only about one half the length of the first row of tubes was exposed to the furnace. In many cases of clinkering trouble, the bridge wall sloped back from a point immediately above the stoker to a point near the rear of the boiler in such a way that nearly the entire length of this first row of tubes was exposed. The result was to absorb more heat from the fuel bed and permit operating at higher capacities without clinker trouble. Fig. 1 shows an installation of this type, both the original bridge wall and the changed bridge wall being indicated.

There are probably many old plants in existence having straight-tube boilers with C-tile on the bottom row of tubes. Experience has indicated that if these C-tile are removed and replaced with T-tile on the second or third row of tubes, the same effect will be produced as in the previous case. Heat is radiated from the fuel bed to these tubes and more coal can be burned before clinkering trouble is encountered.

More water-cooling surface may be required in a particular installation than can be provided merely by exposing an additional length of the first row of tubes. Usually the least expensive addition of such water-cooled surface can be had by placing water tubes over the bridge wall. Frequently, this can be done by replacing the first row of tubes by tubes of such length that they can continue over the face of the bridge wall in such a manner as to constitute bridge-wall cooling. If the boiler is of the bent-tube type, the tubes at the ends of the top front drum can be replaced by other tubes which can be brought down and along the side walls and enter either the lower drum or short vertical headers at the rear of the setting. If none of these methods provides sufficient cooling surface, it may be necessary to replace the entire side walls of the furnace with complete water-tube areas. This will involve the use of both upper and lower headers and proper water-feed and release tubes from the wall.

Certain types of coals are agglutinating and tend to cake in such a manner as to retard the passage of air through the fuel bed. This caking tendency is aggravated at lower furnace temperatures with some coals. It can be reduced by increasing the furnace temperature. If then, such a coal is burned in a furnace having a very large amount of water-cooled surface exposed, sufficient capacity may not be obtained because of the caking action in the fuel bed, resulting from too-low furnace temperature. In such cases, it becomes necessary to apply some refractory surface over at least a portion of the waterwall area, reducing the heat absorption by this portion of the waterwall area, thereby increasing furnace temperature and reducing the caking effect.

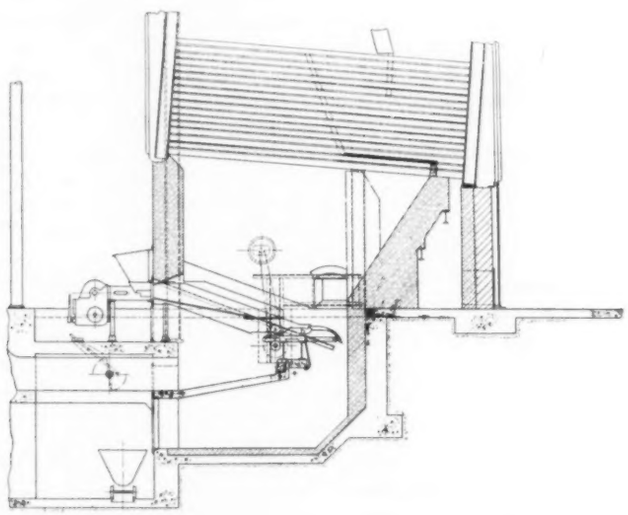

FIG. 1 TO CORRECT CLINKERING TROUBLE, THE BRIDGE WALL IN THIS INSTALLATION WAS CHANGED FROM THE POSITION INDICATED TO ONE EXPOSING THE ENTIRE LENGTH OF THE FIRST ROW OF TUBES

OVERFIRE AIR TO INCREASE CAPACITY

Furnace size or shape may not be suitable for obtaining required capacities with the type of coal which it may be necessary to burn. The furnace volume may be insufficient for completion of combustion at the increased rate. If this is so it will be evidenced by smoke leaving the stack. Usually it is not feasible to increase the size of the furnace. The lack of size can be compensated for by the use of overfire air introduced into the furnace at a short distance above the fuel bed. If this air is properly introduced in a large number of small jets and at sufficient pressure to penetrate the gas streams a sufficient distance, turbulence of the gases will occur in such a way as to bring combustible gases in intimate mixture with free oxygen, and combustion of these gases will be completed before entering the tube bank.

Such overfire air is of use both for underfeed stokers and traveling-grate stokers. A fair average requirement for overfire air is 15 per cent of the total air for combustion, this air having a pressure of 10 in. at the nozzles. A separate fan for blowing this air into the furnace is desirable. Those installations having forced-draft fans for delivering air under the grates can take overfire air from the air ducts, but this is usually inadequate because of the lower pressures commonly used in such an operation. Such an arrangement is particularly undesirable if air control is by means of forced-draft fan inlet dampers, or if the fan is of the variable-speed type. If air is controlled by dampers at the discharge of the fan, overfire air should be taken off at a point between the fan and this damper.

INFLUENCE OF ARCH DESIGN

Changes may be made in furnace shapes by means of arches or by changes in arches, both for the purpose of promoting ignition of incoming fuel and for mixing the gases. Free-burning midwestern coal ignites rather easily and is not so dependent upon arch construction for radiation of heat for ignition. More open furnaces can be used. With open furnaces, however, it is quite essential that overfire air be used for mixing and turbulence. Eastern coals do not ignite so easily, and more consideration must be given to arch design in order to radiate heat onto the incoming coal. In either case, properly designed arches produce gas turbulence in the furnace, aid in completing combustion, reduce the necessity for overfire air, and, because combustion is completed in a smaller space, promote increase in capacity.

Capacity is frequently restricted because of lack of air or lack of draft. These restrictions may be due to deficiency of forced-draft or induced-draft fans. Capacity of these fans frequently can be increased by operating them at higher speeds. If increasing fan speed does not produce the desired results, it may be necessary to change the diameter of the wheels in the fan housings or even to install new fans.

Draft capacity is the ability for taking away gases of combustion and delivering them to the stack. Anything that acts to restrict the passage of these gases restricts draft capacity. If the fuel-burning equipment receives air from a forced-draft fan and an attempt is made to increase capacity by delivering more air to the fuel bed, a condition may result in which the ability to remove gas is insufficient and a positive pressure will be created in the furnace. This positive pressure causes a rise in furnace temperature, clinkering in the fuel bed, high maintenance in the fuel-burning equipment, and high maintenance of the furnace setting. In such cases, a study should be made of the design of baffles in the boiler and the design of gas ducts between the boiler and stack. Frequently, a row of baffle tile can be removed without affecting the final flue-gas temperature by so opening up the passages or reducing the sharpness of turns that more gas can be passed through the setting with the same available draft. The areas of passageways between baffles should be carefully studied to make sure there are no restrictions and that the areas decrease in the direction of gas travel, approximately in proportion to the decrease in gas volume.

Usually gas ducts are of sufficient area. Undue pressure drops are often found at turns or bends. A sharp turn is the greatest offender. Frequently, a large increase in draft capacity can be obtained by changing the bend from a sharp inside corner to a long-radius curve. The author knows of one case of a natural-draft installation in which the steam-generating capacity of the boiler was doubled by making this kind of a change in the gas duct going to the stack.

PULVERIZED-COAL INSTALLATIONS

This discussion so far has been confined to installations fired by means of stokers. This is because there are more stoker installations in use which have been in service for many years and in which the original design did not contemplate demands such as those of today. Most boilers fired by means of pulverized coal are of later installation and are designed for present-day practice. However, many of the older pulverized-coal-fired boilers still have all-refractory furnaces, operate on natural draft, and are subject to restrictions very similar to those in the cases already described for stoker firing. In many of these cases, similar remedies apply, as those which have been described.

If pulverized coal is burned in an all-refractory furnace, frequently there are possibilities for very great increases in capacity by the addition of a water-cooled surface. For a given desired capacity and with the use of a given kind of coal, it is possible to estimate quite closely how much water cooling should be applied. Usually, these all-refractory furnaces are quite large in proportion to the steaming capacity of the boiler as originally installed. With the addition of water-cooled surface, and with this large furnace volume, increased heat release can be obtained, without the rate of heat release per cubic foot of furnace volume or per square foot of exposed water-cooled surface exceeding present standards.

The same problems in connection with limitations of draft are encountered in pulverized-coal firing as in stoker firing. The solution of draft problems is the same as that described for stoker firing.

However, other types of problems are encountered which do not exist in the case of stoker firing. The pulverizer itself may constitute a definite limit to the capacity which can be obtained. If a pulverizer has been installed with just sufficient capacity for grinding the required amount of coal of 100 grindability, it will be very deficient if required to grind coal of 50 grindability. There may be possibilities in increasing the capacity of a given pulverizer to meet this particular problem, but it may also be necessary to install additional pulverizers to maintain or even increase the capacity. If coal comes to the pulverizers unusually wet, then the coal-grinding capacity will be reduced. This can be partially compensated for by supplying air to the pulverizer at a temperature higher than that previously used. This may involve the installation of some form of air heater. If higher-temperature air cannot be had, then more heat may be supplied to the pulverizer by use of hot gas from the furnace.

Too much water-cooled surface in a furnace can have an adverse effect on pulverized-coal firing. Free-burning midwestern coals can be more successfully fired in completely water-cooled furnaces than can eastern coals which are not so free-burning. In any case, complete water cooling, to various degrees, causes an increase in unburned carbon. This is usually tolerated since the furnace giving the minimum carbon loss, which would be

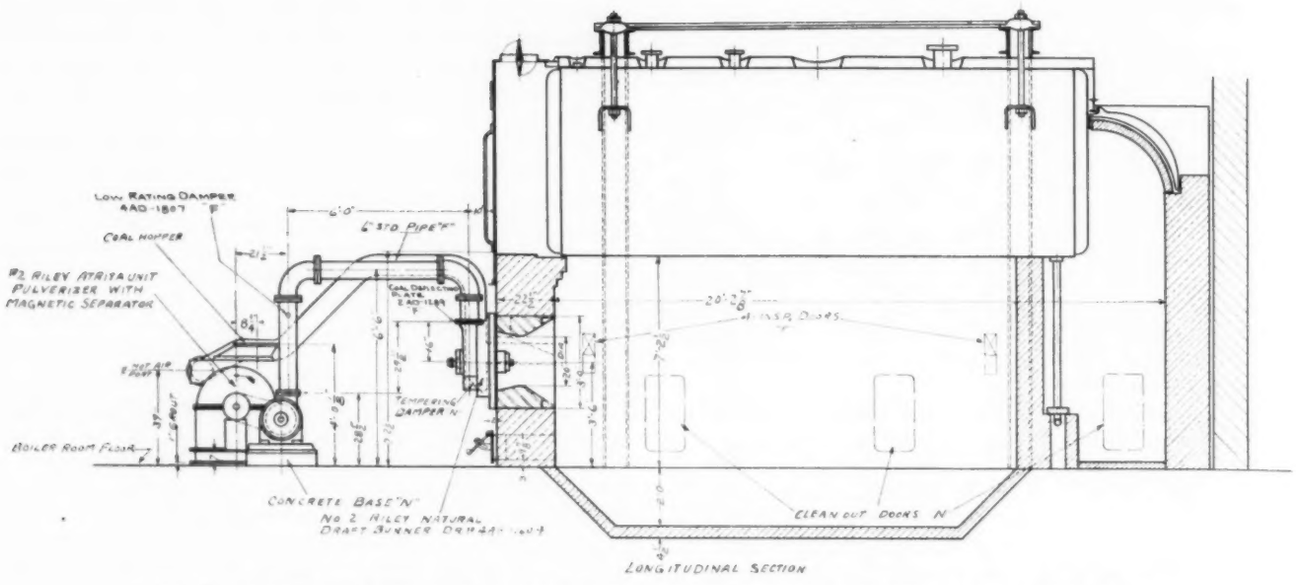

FIG. 2 EXAMPLE OF LOWERING FURNACE FLOOR TO PREVENT ASH FROM FUSING INTO A SOLID MASS

an all-refractory furnace, would need to be so large as to make first cost prohibitive. Also, complete water cooling of a furnace may affect stability of ignition and the range of load that can be carried. In such cases, it may be necessary to supply refractory to the water-cooled walls in the same manner as previously described.

If the supply of coal to a pulverized-coal installation is changed and the new coal has ash which fuses at a lower temperature than that previously used, capacity can be limited because of slagging of the ash. This slagged ash will not only accumulate on the furnace walls in large quantities but will also accumulate in the gas passes of the boiler, restricting the flow of gases to such an extent as to reduce ratings. Application of additional water-cooled surface to the furnace is one solution to this problem. However, this may not be possible or expedient. In such cases, furnace temperatures can be prevented from rising to such an amount as to slag the ash, by increasing the amount of excess air. The extra amount of air increases the weight of the total products of combustion, with the result that the total sensible heat remaining in the gases is divided up among more pounds of gas, causing a lower gas temperature.

Frequently, in older pulverized-coal installations, the furnace bottoms were flat and ash was removed through cleanout doors at the operating-floor level. These installations were satisfactory to meet the requirements for which they were designed. If, however, they are required to burn coal with lower-fusion ash or to burn more coal, the ash on this furnace bottom fuses into a solid mass. This occurs because of the short distance from the underside of the flame to the floor. The answer to this problem is to move the floor farther away from the flame. An example of this is shown in Fig. 2. The installation is small, being a horizontal return-tubular type of 150 hp. The original floor was level with the boiler-room floor. The design was made for use with Eastern Kentucky coal. Later it became desirable to burn Western Kentucky coal. Slagging then occurred on the furnace bottom. The furnace was excavated to the level, shown in Fig. 2. Slagging on the floor was entirely eliminated.

CHANGING FROM OIL TO COAL FIRING

At the present time along the Atlantic seaboard many plants are faced with the necessity to change from oil firing to coal firing. Many of these plants were designed so that either fuel could be used. Fig. 3 shows a typical installation. This is a boiler having a capacity of 300,000 lb of steam per hr and is installed in an oil refinery. At the time of the original installation no pulverizers were installed, but the furnace was so designed that full capacity could be obtained with pulverized coal in case it became necessary to burn coal. Because of the present oil situation in this territory, this plant has installed pulverizers and is firing these boilers with coal. The oil saved is made available for more critical use.

However, many boilers have been installed in this area with furnaces designed for oil firing that are entirely inadequate for coal firing. Such plants must of necessity make major changes in the furnaces when changing to coal. Changing from oil firing to coal firing involves making the decision whether to fire coal by hand, by stokers, or with pulverizers. Many of the boilers are sufficiently small so that they can be fired by hand, a

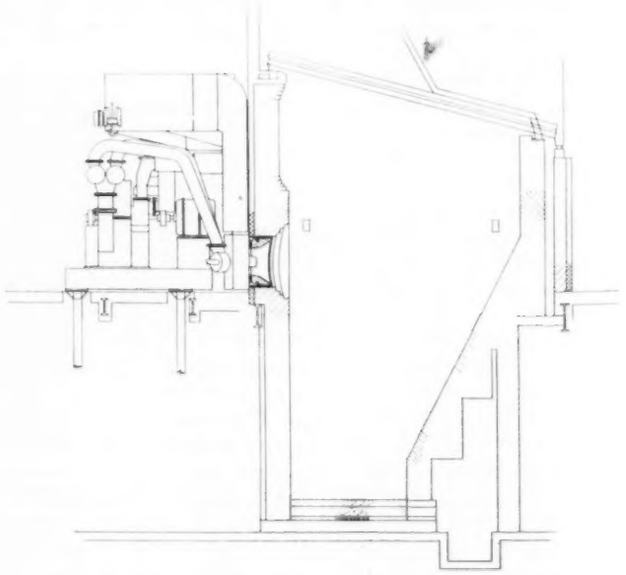

FIG. 4 BOILER INSTALLATION CONVERTED FROM OIL TO PULVERIZED-COAL FIRING IN WHICH INTERFERENCE WITH OTHER EQUIPMENT MADE NECESSARY A FURNACE OF PECULIAR SHAPE

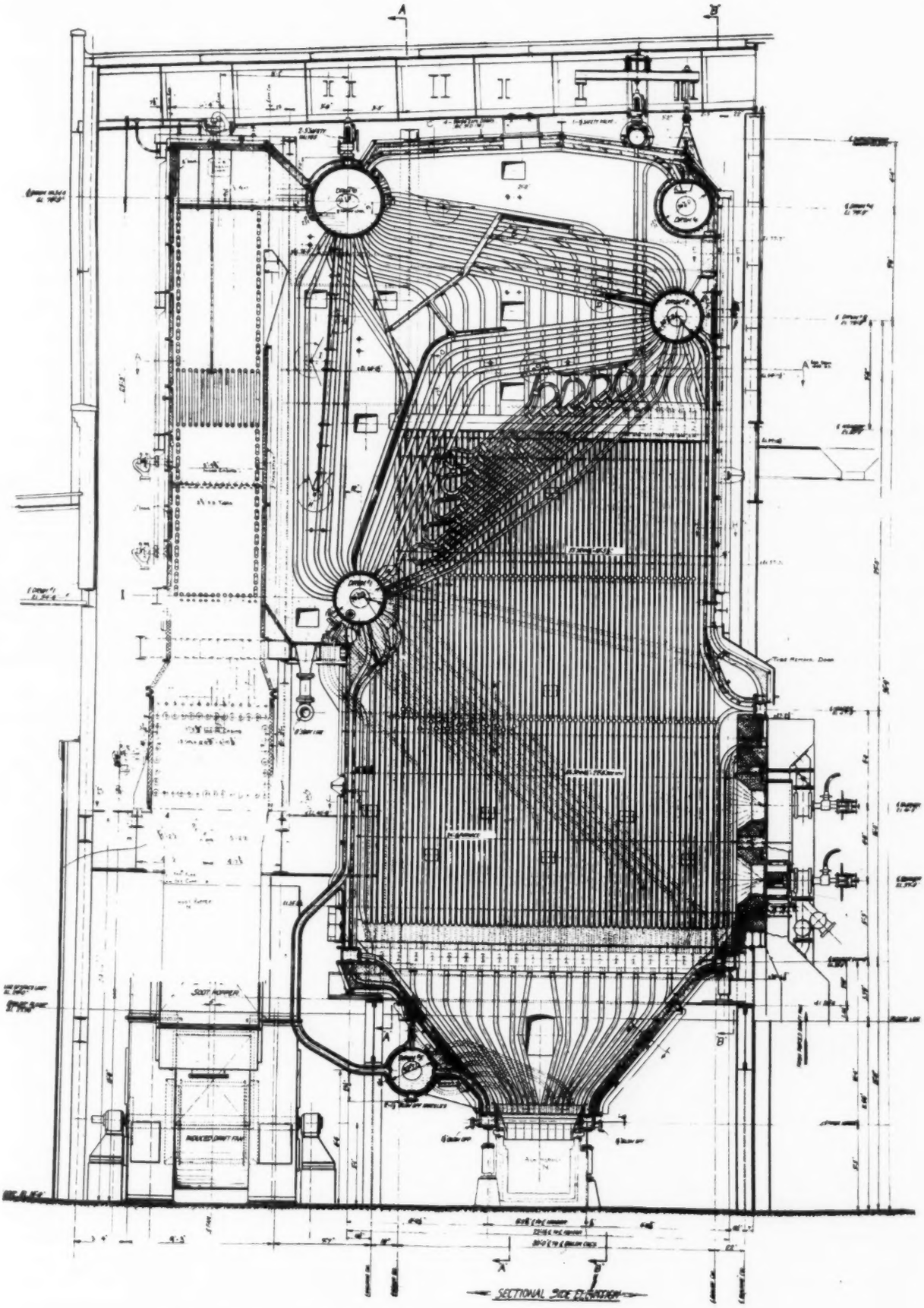

FIG. 3 TYPICAL BOILER INSTALLATION WITH FURNACE DESIGNED TO BURN OIL OR PULVERIZED COAL

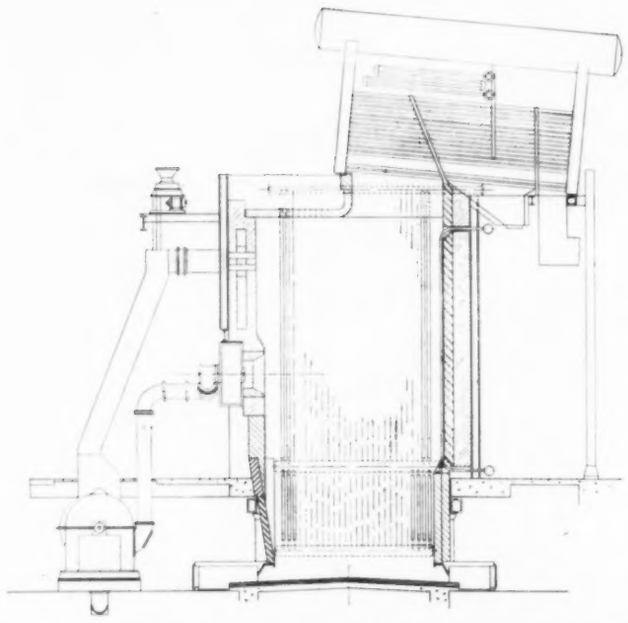

FIG. 5 THIS OIL-FIRED FURNACE WHEN CONVERTED TO PULVERIZED-COAL FIRING, WHILE OF AMPLE SIZE, REQUIRED ADDITIONAL WATER-COOLED SURFACE, AND HOPPER BOTTOMS WERE INSTALLED

minimum of expense being involved. However, for larger boilers, stokers or pulverizers must be used. If the furnaces are rebuilt and stokers installed then oil cannot be used when it becomes available and cheaper than coal. If the furnaces are redesigned so as to be suitable for pulverized-coal firing, and pulverizers are installed, then, usually, the existing oil equipment can be incorporated into and with the new equipment, and coal or oil can be burned alternately as one or the other may be available or more economical.

In changing over from oil firing to pulverized-coal firing, it is sometimes necessary to make compromises in furnace designs because of interferences with other equipment in the plant. Fig. 4 shows an installation which was converted from oil firing to coal firing and in which such interferences did occur. The result was to produce a rather peculiarly shaped furnace. A very high furnace was designed, since it was desirable to bring the furnace bottom to the basement floor, this being the point for easiest removal of ashes. The long slope at the rear of the furnaces was necessary because of the location of certain ducts and piping which could not be removed. However, the furnace has proved satisfactory, the desired capacities have been obtained, and oil can be fired at equal capacities whenever it becomes desirable.

Sometimes an oil-fired furnace is of sufficient size to accommodate pulverized-coal firing but lacks only sufficient water-cooled surface. Fig. 5 shows such an installation. This boiler is installed in an oil refinery located in the Middle West. Oil was fired through the furnace arch. When pulverizers were installed, the amount of water-cooled surface was increased and water-cooled hopper bottoms were added. With these changes the same capacity is obtained with midwestern coal as was previously obtained by oil firing.

Frequently, increased capacity can be obtained with an installation fired by multiple-retort underfeed stokers, when burning inferior coals, by removing the stokers, rebuilding the furnace, and applying pulverized-coal firing. Such an installation is shown in Fig. 6. There were four boilers in this plant, and, initially, the furnaces of two were rebuilt, one pulverizer being installed for serving the two boilers. Subsequently, the other two furnaces were rebuilt and two additional pulverizers installed. The furnaces, as originally rebuilt, were entirely refractory. Because of the economies to be had by buying lower-grade coal, waterwalls were added to the rear walls. The result has been increased capacity with increased efficiency and much lower fuel cost of steam.

This discussion does not cover all the problems that will be encountered with fuel because of war conditions. It does attempt, however, to point out the problems which are of more frequent occurrence and to indicate suitable solutions.

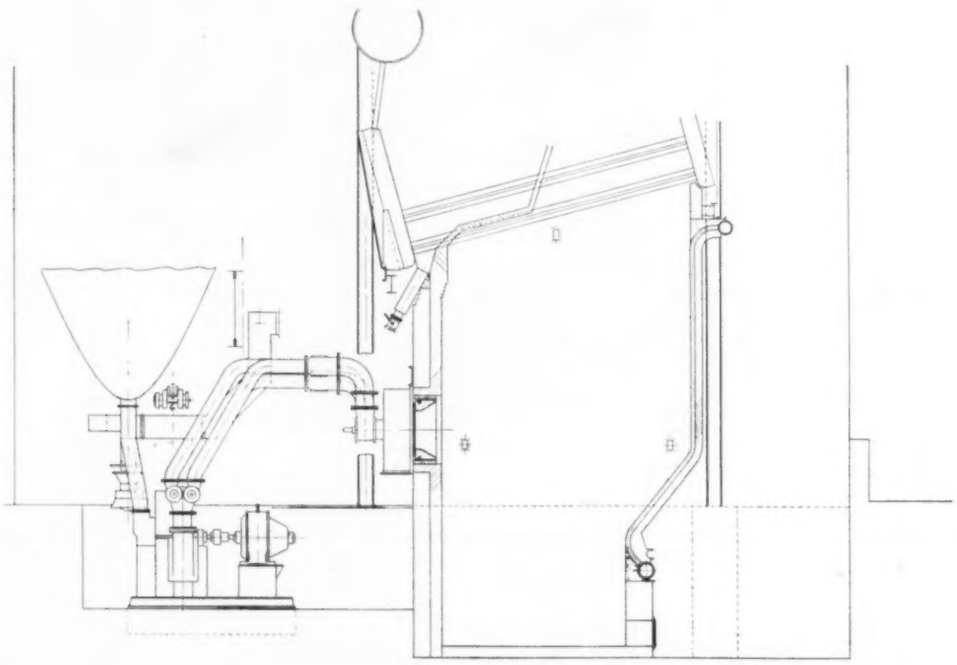

FIG. 6 INSTALLATION IN WHICH MULTIPLE-RETORT UNDERFEED STOKERS WERE REPLACED BY PULVERIZED-COAL FIRING

Development of STANDARDS *for* ARMY ORDNANCE FINISHES

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INTRODUCTION

AS USED in this paper, "ordnance finishes" are those surfaces produced during the final machining of metal components of ordnance material. For the benefit of the design, production, and inspection units of the Ordnance Department, the relative roughness and smoothness of such surfaces are identified by means of a series of symbols listed in "Drafting Room Regulations of the Ordnance Department, U. S. Army," revised April 2, 1941. The following extract from these regulations defines the symbols:

g Requires a coarse grind or file finish for the purpose of smoothing up and improving the appearance of an unmachined surface upon which no stock is to be removed but does not include the removal of fins, etc., from castings and forgings, which must be done without any special symbol.

cf Requires a coarse machine, chipping, or grind finish applicable to clearance cuts or surfaces which are finished to insure the avoidance of interference, or excess metal in walls of castings.

f Requires a machine finish of good quality, such as is properly applicable to surfaces fitting together but not moving on each other.

ff Requires the finest grade of machine finish. If the work is such as to demand it, the symbol also includes scraping and draw filing. This finish should be used for all ordinary bearing surfaces.

fg Requires a fine grind finish for important steel bearing surfaces and those carrying heavy loads. Such a finish is usually produced by the use of fine abrasive wheels and includes lapping and polishing where the work requires it.

Ordnance practice for defining finishes has been analogous to schemes which industry employs. The chief weakness of such systems has been the failure to associate drawing symbols with definite standards of surface roughness. This permits unlimited interpretation of any one symbol.

The need of standardizing finishes on war matériel and the importance of uniform interpretation of finish requirements on drawings have been appreciated by individuals within the organization. It has been awaiting the developments of a national standard of surface finishes through the mechanism set up by the American Standards Association, the organization recognized by the country's various engineering groups as the one properly qualified to pursue standardization projects.

That the development of a national standard of surface finishes has been in progress during the last decade is proof that industry also has been conscious of the necessity of standardizing the finishes made by cutting tools and by grinding wheels on the metal components of its products. The development work has been carried out by the American Standards Association Committee B46 which was established in 1932, under the sponsorship of The American Society of Mechanical Engineers and the Society of Automotive Engineers. Impetus to the organization of this committee had been given by two papers (1, 2),[1] published in 1931, in which the authors had advocated the standardization of surface finishes on a national basis. One of these authors, Deale, had even stated:

"A national standard would be particularly desirable for Ordnance work, which, in time of emergency, may have to be done in any shop in the country."

A proposed American Standard, "Surface Roughness," compiled by American Standards Association Committee B46 was placed at the disposal of industry in March, 1940, for a trial period not to exceed 2 years. This proposal (3) (see Table 1) recommends that the roughness of a surface be expressed by a numerical value,[2] namely, the root-mean-square deviation of the surface profile from its central line, in μ in. (microinches). Fourteen main classes of surface roughness, each represented by a maximum permissible root-mean-square value, are proposed. The fourteen values step up in accordance with the

TABLE 1 PROPOSED AMERICAN STANDARD: SPECIFICATION FOR SURFACE ROUGHNESS

Roughness symbol	Root-mean-square height of irregularities[a] Inches	Microinches
63M	0.063	63000
16M	0.016	16000
4M	0.004	4000
1M	0.001	1000
250	0.00025	250
63	0.000063	63
32	0.000032	32
16	0.000016	16
8	0.000008	8
4	0.000004	4
2	0.000002	2
1	0.000001	1
1/2	0.0000005	1/2
1/4	0.00000025	1/4

[a] Method of calculating root-mean-square height of irregularities from measured values, $a - m$

a =	4	a^2 =	16
b =	19	b^2 =	361
c =	23	c^2 =	529
d =	16	d^2 =	256
e =	−31	e^2 =	961
f =	−20	f^2 =	400
g =	−27	g^2 =	729
h =	20	h^2 =	400
i =	31	i^2 =	961
j =	13	j^2 =	169
k =	−23	k^2 =	529
l =	−15	l^2 =	225
m =	− 6	m^2 =	36
		Total	5572

$$\text{rms avg} = \sqrt[2]{\frac{5572}{13}} = \sqrt[2]{428.6} = 20.7\ \mu\text{ in.}$$

Contributed by the Production Engineering Division and presented at the Semi-Annual Meeting, Cleveland, Ohio, June 8–10, 1942, of The American Society of Mechanical Engineers.

[1] Numbers in parentheses refer to the Bibliography at the end of the paper.

[2] A microinch is one millionth of an inch.

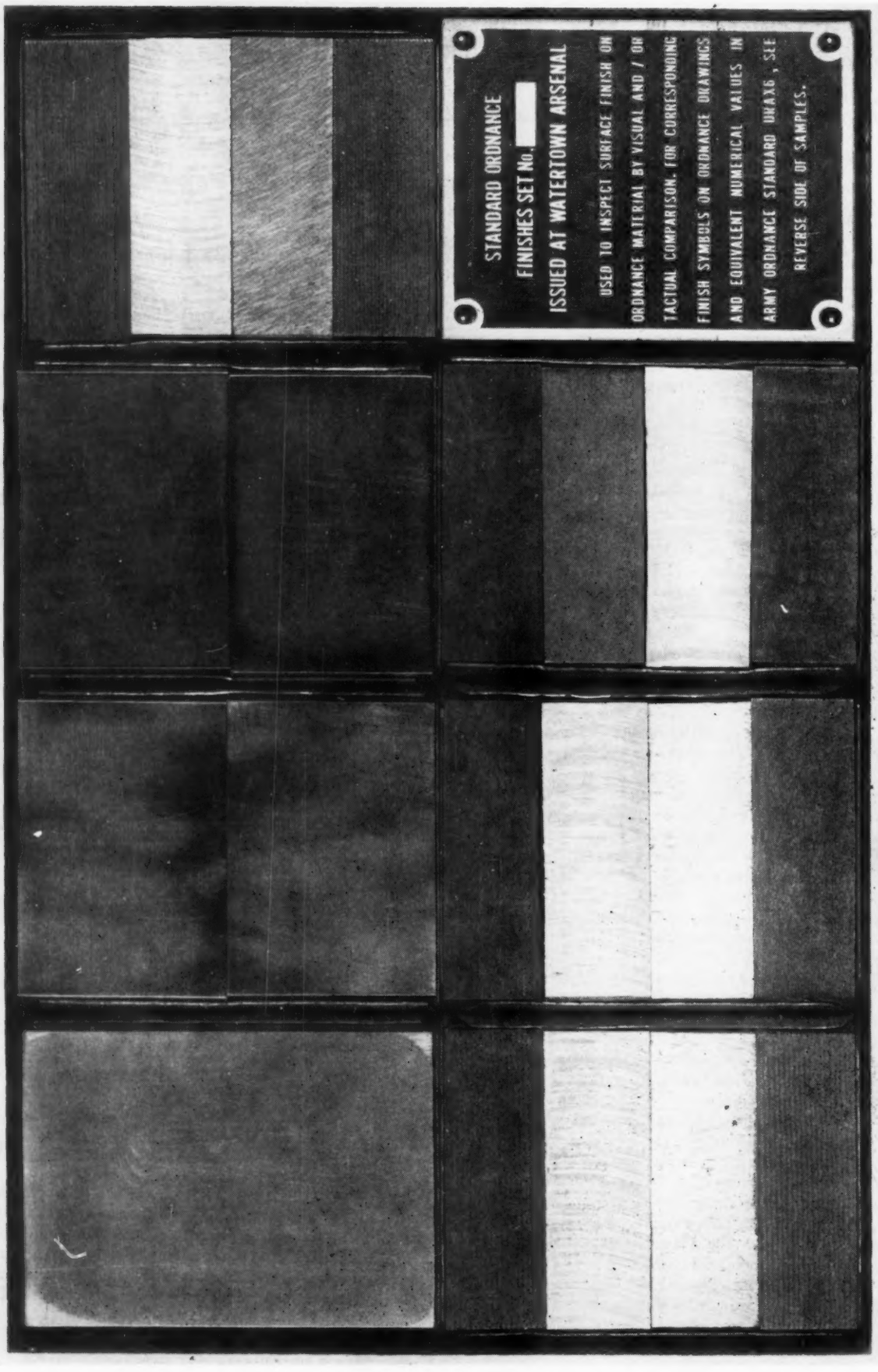
STANDARD ORDNANCE
FINISHES SET No.
ISSUED AT WATERTOWN ARSENAL
USED TO INSPECT SURFACE FINISH ON ORDNANCE MATERIAL BY VISUAL AND / OR TACTUAL COMPARISON. FOR CORRESPONDING FINISH SYMBOLS ON ORDNANCE DRAWINGS AND EQUIVALENT NUMERICAL VALUES IN ARMY ORDNANCE STANDARD OMAX6, SEE REVERSE SIDE OF SAMPLES.

FIG. 1 SET OF STANDARDS OF ORDNANCE FINISHES
(Arrangement of samples in box to be used by inspector.)

twenty series of "preferred numbers."[3] If none of these classes suits the designer, he can make a choice from nineteen subclasses based on the forty series of "preferred numbers." The standard recommends a system of specifying roughness classes on drawings, namely, the V-shaped character $\vee$ to indicate finish roughness, values being inserted in the opening of the V, e.g., $\overset{3}{\vee}$. The two-year trial period ended in March, 1942. Changes in the draft of the proposed standard are anticipated.

The War Department had representation on Committee B46. When the proposed American Standard was issued in 1940, a copy was circulated throughout the Ordnance Department. Reaction was favorable and indicated that the department should subscribe to the major features of the standard. One comment was as follows:

". . . . . In case of war production, there will be a necessity for interpreting finish requirements in each of the Ordnance Districts. Difficulties may be anticipated due to the lack of quantitative standards in the Department's present practice."

Even before the trial period of the proposed American Standard ended, war production did arrive. The predicted difficulties concerning the interpretation of surface finishes did arise. The urgent need for standardizing finishes, in order to assist both the industrial contractors for war matériel and the inspectors in the Ordnance Districts, was recognized. Under the sponsorship of General R. H. Somers, a Surface Finish Committee was formed. The members represented different sections as follows: Artillery Division, E. J. Almquist, chairman; Research and Engineering, Major W. J. Darmody; Ammunition Division, E. R. Roach; Tank and Combat Division, E. K. Smith; Small Arms Division, L. A. Carten; Inspection, A. T. Stamp.

The committee had two commissions:

1 To establish definite values for the degrees of finish required on different components of matériel, that is, for the degrees of finish now represented by symbols such as F, FF, and FG on ordnance drawings.

2 To devise a set of reference samples which would serve as standards for inspection purposes.

Although data on which standards are to be based should be accumulated systematically over a reasonable period of time, the committee found it necessary to disregard normal procedure and to utilize those data which could be obtained rapidly. This was done by requesting each of the six manufacturing arsenals to submit samples representing its interpretation of the current finish symbols on drawings. More than one hundred samples were included in the group. The roughness of each piece was measured by a commercial instrument which records a numerical value for the degree of finish. Data secured in this manner were used to formulate the series of numerical values contained in drawing URAX6 shown in Table 2. The actual standards are the reference samples which have been calibrated to the values listed in URAX6 and a set of which constitutes an inspector's gage. Fig. 1 illustrates a set of these standards. Both Table 2 and Fig. 1 will be discussed in detail later.

This entire project adheres to the ideas expressed by Gaillard (4) whose suggested working plan for introducing standardization into an individual organization involves the following steps:

1 Survey of existing practice.
2 Study of results of survey.
3 Formulation of proposals for . . . . standards.

Precedent for the method of collecting data had already been set by a much broader project undertaken in England (5). The Institution of Production Engineers, in an effort to provide standards for the measurement of surface finish, secured data on existing limits of surface roughness by measuring 434 surfaces obtained from nineteen leading British firms manufacturing the following twelve products: Automobiles, commercial vehicles, airplanes, rolling stock, machine tools, electrical machines and equipment, precision instruments, gears, roller bearings, fuel injectors, gages, and standards. The work involved a comparison of results obtained by different surface-measurement devices. It was carried out during the period from August, 1939, to March, 1941. The proposal for a British standard shown in Table 3 was based upon the results of this study.

[3] American Standard for Preferred Numbers Z17.1–1936.

TABLE 2 ORDNANCE FINISHES

Matériel	F 250	F 175	F 125	F 63	FF 63	FF 32	FF 16	FG 16	LAP 8
Artillery carriage and cannon:									
"F" finish for nonmating parts	X	..	..	..	..	..	..	..	..
"F" finish for mating parts	..	..	X	..	..	..	..	..	..
Other finishes	..	..	..	..	..	X	..	X	X
Fire control	..	..	X	..	..	X	..	X	X
Small arms	..	..	..	X	..	X	..	X	X
Tank and combat vehicles	..	..	X	..	..	X	..	X	X
For bearings	..	..	..	..	..	..	X	..	..
Artillery ammunition:									
Shell, steel, Spec. 50-30-1	X	..	..	..	X	..	..	..	..
Shell, steel, Spec. 50-30-4	..	..	X	..	X	..	..	..	..
Shot, A.P. and Semi, A.P. maj. cal	X	..	..	..	X	..	..	..	..
Shot, A.P. and Semi, A.P. incl. 3 in.	..	X	..	..	X	..	..	..	..
Shell, smooth-bore mortar	X	..	..	..	..	X	..	..	..
Cartridge cases, primers, boosters, bursters, fuses, pyrotechnics, grenades, and mines	..	..	..	X	..	X	..	X	X

NOTES:

1 Standard Ordnance Finishes are for the use of the inspectors in the acceptance of ordnance matériel produced in accordance with the finish symbols shown on ordnance drawings.

2 Inspection of surface finish will be by visual and/or feel comparison between the Standard Ordnance Finishes and the item or component being inspected.

3 The standard reference samples represent the roughest surfaces acceptable under each finish classification for the particular matériel designated herein.

4 The numerical values shown opposite the finish symbols herein are the root-mean-square (rms) roughness values in μ in. used to calibrate the standard reference samples.

5 For description of finishes governed by these reference samples, see the applicable General Specifications for the ordnance matériel under inspection.

TABLE 3 PROPOSAL FOR A BRITISH STANDARD

Roughness class number	h_{ave} — h_{rms} (microinches)	Symbols for drawings and workshop	
0	0 — 1	Turning	= *T*
1	1.1 — 2	Diamond turn	= *DT*
2	2.1 — 4	Grinding	= *G*
3	4.1 — 8	Honing	= *H*
4	8.1 — 16	Lapping	= *L*
5	16.1 — 32	Polishing	= *Po*
6	32.1 — 63	Boring	= *B*
7	63.1 — 125	Diamond boring	= *DB*
8	126 — 250	Reaming	= *R*
9	251 — 500	Milling	= *M*
10	501 — 1000	Planning	= *P*
(11)[a]	1001 — 2000	Scraping	= *S*
(12)[a]	2001 — 4000	Broaching	= *Br*

[a] Classes (11) and (12) for rough classification only.

Symbols on drawings:

$\overline{L}\ \overset{1}{\vee}$ = Lapping—Class 1
$\overline{T}\ \overset{4}{\vee}$ = Turning—Class 4
$\overline{M}\ \overset{9}{\vee}$ = Milling—Class 9

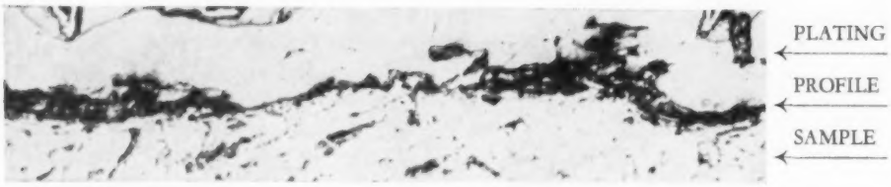

FIG. 2(*a*) STEEL SURFACE CUT WITH POWER HACKSAW; ×200
(Approximately 35μ in. rms.)

FIG. 2(*b*) PORTION OF FIG. 2(*a*); ×2500

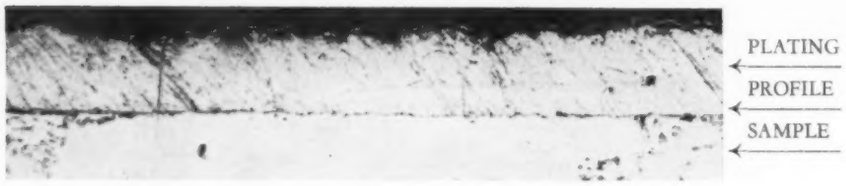

FIG. 3(*a*) STEEL SURFACE CUT WITH SURFACE GRINDER; ×200
(Approximately 10 μ in. rms.)

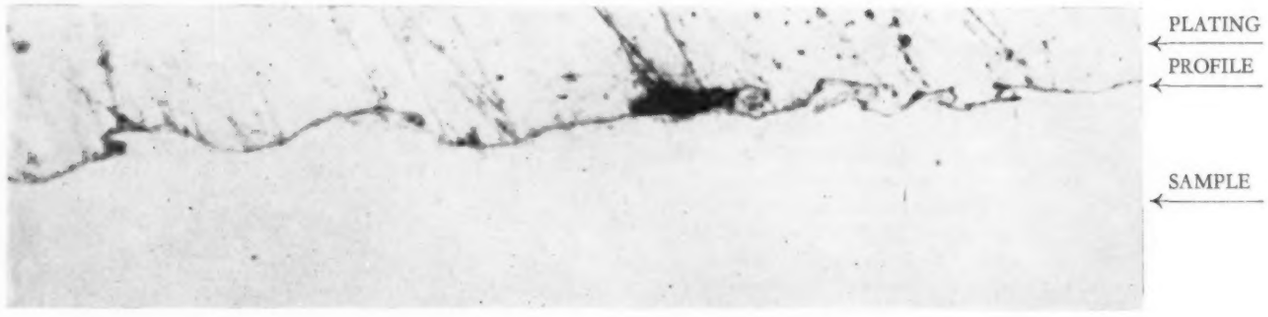

FIG. 3(*b*) PORTION OF FIG. 3(*a*); ×2500

PROCEDURE FOR STANDARDIZATION OF ORDNANCE FINISHES

Samples Submitted for Use in Development of Ordnance Finish Standards. Each of six manufacturing arsenals was requested to submit samples representing the interpretation given in its shop to the current finish symbols on (ordnance) drawings; that is, for the letters G, CF, F, FF, and FG. Table 11 lists the samples, together with machinery data as supplied by each.

Study of Table 11 reveals that some shops offered production surfaces while others prepared special pieces with toolroom technique, that most shops used steel samples, and that some shops recorded machining data more completely than did others. This was due largely to the fact that the samples had to be prepared hastily and with the minimum stoppage of production work. They were accepted for this study with the recognition that they would provide a wide range of values for finish measurements.

Method of Measuring Surface Roughness[4] *of Samples Submitted for*

[4] The expressions "surface finish" and "surface roughness," as used in this discussion, have the same connotation as the word roughness which is defined in the following manner by the proposed American Standard:

"*Roughness.* Recurrent or random irregularities in a surface which have the form of small waves or bumps. Roughness may be considered as being superimposed upon a nominal surface or upon a wavy surface. On 'smooth-machined' surfaces, the distance between the 'high spots' of such irregularities is ordinarily between 0.0002 and 0.010 in., and their height is very much less than their width, usually being between 0.000001 and 0.0005 in. Similar dimensions for the irregularities in surfaces which are coarser or rougher than those generally classified as 'smooth-machined' will be proportionately larger."

Development of Ordnance-Finish Standards. Various methods have been advocated to evaluate surface roughness. The limitations and relative merits of some of them have been discussed at length by Schmaltz (10), Way (6), and Schlesinger (5).

Surface irregularities may be studied as follows:

1 In profile:

(*a*) By the principle of optical cut (10, 6).

(*b*) By plating the surface, cross-sectioning it, and polishing it for microscopic study.

(*c*) By measuring the surface with an instrument which traces the irregularities with a diamond stylus and records the measurement as a numerical value.

2 On a plan view:

(*a*) By means of the microscope.

(*b*) By means of the interferometer.

Possible limiting sizes of irregularities which may be revealed by each of these methods are recorded in Table 4. Some of these values are taken from the literature on surface finishes (5, 6). Those for photomicrography were calculated from data (8, 9, 11), giving the relationship of theoretical resolving power in number of lines per inch, numerical aperture of the objective, and dominant wave length of light in Angstrom units.

Figs. 2, 3, and 4 illustrate irregularities on steel surfaces as revealed by method 1(*b*). Fig. 2(*a*) (×200) and Fig. 2(*b*) (×2500) show the profile of the same sample cut with a power hacksaw; Fig. 3(*a*) (×200) and Fig. 3(*b*) (×2500) that of the same sample finished on a surface grinder with a Norton 3846 wheel; Fig. 4(*d*) (×200) and Fig. 4(*e*) (×2500) that of the same superfinished sample. The profiles indicate a decreasing roughness of the surface. This is corroborated by measurements obtained with a tracer-point instrument according to method 1(*c*). Readings of approximately 350, 10, and 3 (μ in., root mean square) were recorded for the three surfaces.

It may be observed that method 1(*b*) fails to be quantitative in the case of the relatively smooth superfinished sample. That this is due to limitations of the method[b] itself and not to limitations of microscopic resolution is evidenced by Figs. 4(*a*), 4(*b*), and 4(*c*), which illustrate a plan view of the same sample shown

[b] The taper section method employed at Battelle Memorial Institute minimizes these limitations, (7).

TABLE 4 POSSIBLE LIMITING SIZES OF IRREGULARITIES REVEALED BY DIFFERENT METHODS OF EVALUATING SURFACE FINISH

Method	Limiting size of irregularity, in.
1 Optical cut, straight-edge projection device (Schmaltz)	0.00001[a]
Optical cut, straight-edge shadow process (Way)	0.00003—0.00005[a]
2 Tracer point instrument, profilometer (Abbott, U.S.A.)	0.00001[a, b]
Tracer point instrument, brush analyzer (U.S.A.)	0.00001[b]
Tracer point instrument, profile recorder (Schmaltz, Germany)	0.00001[b]
Tracer point instrument, Taylor-Hobson surface meter (England)	0.000008[a]
3 Photomicrography (Objective: 0.95 N.A.; filtered light, λ = approx 4500A)	0.00001[c, d]
(Same as previous item but with oblique illumination)	0.000005[e]
(Objective: 1.4 N.A.; filtered light, λ = approx 4500A)	0.000006[c, d]
(Same as previous item but with oblique illumination)	0.000003[e] approx
(Objective: 1.6 N.A.; filtered light, λ = approx 4500A)	0.000005[c, d]
(Same as previous item but with oblique illumination)	0.000003[e] approx
4 Microinterferometer	0.000002[a]

[a] Reference (6). [c] Reference (8). [e] Reference (11).
[b] Reference (5). [d] Reference (9).

TABLE 5 SUMMARY OF SURFACE-ROUGHNESS MEASUREMENTS

(Values = instrument readings, microinches root mean square)

Finish definition — G		CF		F		FF		FG		Lap	
Sample[a] no.	μ in. rms	Sample[a] no.	μ in. rms	Sample[a] no.	μ in. rms	Sample[a] no.	μ in. rms	Sample[a] no.	μ in. rms	Sample[a] no.	μ in. rms
A-4	150	A-4	175	A-4	100	A-4	30	A-1	3.0	B-10	A-7
A-5	103	A-5	400	A-5	80	A-5	16	A-2	3.5	C-7d	A-0
A-6	102	A-6	400	A-6	63	A-6	19	A-3	3.5	..	..
B-11	110	C-3a	175	B-5	250	B-1	70	A-4	20.0	..	..
B-12	55	D-3a	317	B-6	175	B-2	55	A-5	4.0	..	..
C-7a	45	D-3b	200	B-7	55	B-3	14	A-6	4.0	..	..
C-7b	30	D-3c	450	B-8	40	B-4	20	B-9	6.6	..	..
C-10b	45	D-6a	83	C-1a	175	C-2	12	C-4a	20.0	..	..
D-1	350	D-6b	267	C-1b	225	C-3b	77	C-5a	30.0	..	..
D-2	258	D-6c	275	C-1c	72	C-3c	50	C-5b	6.7	..	..
E-5a	67	D-12	300	C-1d	150	C-8b	50	C-6a	18.0	..	..
E-5b	80	D-14	217	C-4b	87	D-8a	62	C-6b	3.8	..	..
..	..	E-3a	175	D-7a	225	D-8b	53	C-6c	3.2	..	..
..	..	E-3b	158	D-7b	208	D-10a	40	C-7c	15.0	..	..
..	..	F-8	350	D-9a	200	D-10b	45	C-8a	5.5	..	..
..	..	F-9	250	D-9b	225	D-11b	40	C-9a	15.0	..	..
..	..	..	..	D-11a	167	D-13b	40	C-9b	10.0	..	..
..	..	..	..	D-13a	150	E-2a	22	C-10a	15.0	..	..
..	..	..	..	E-1a	68	E-2b	28	D-4	54.3	..	..
..	..	..	..	E-1b	45	F-1	35	D-5	58.0	..	..
..	..	..	..	F-3	158	F-2	18	E-4b	10.0	..	..
..	..	..	..	F-4	45	..	..	E-4a	8.0	..	..
..	..	..	..	..	..	..	..	F-5	70.0	..	..
..	..	..	..	..	..	..	..	F-6	35.0	..	..
..	..	..	..	..	..	..	..	F-7	12.0	..	..

[a] Prefixed letters refer to shops which prepared the sample.

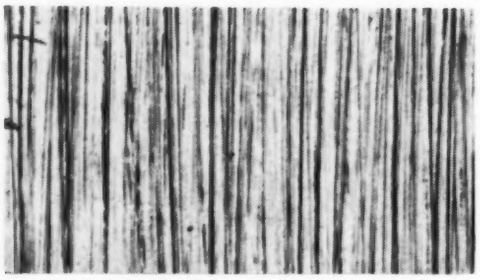

FIG. 4(*a*) SUPERFINISHED SURFACE; ×200
(3 μ in. rms.)

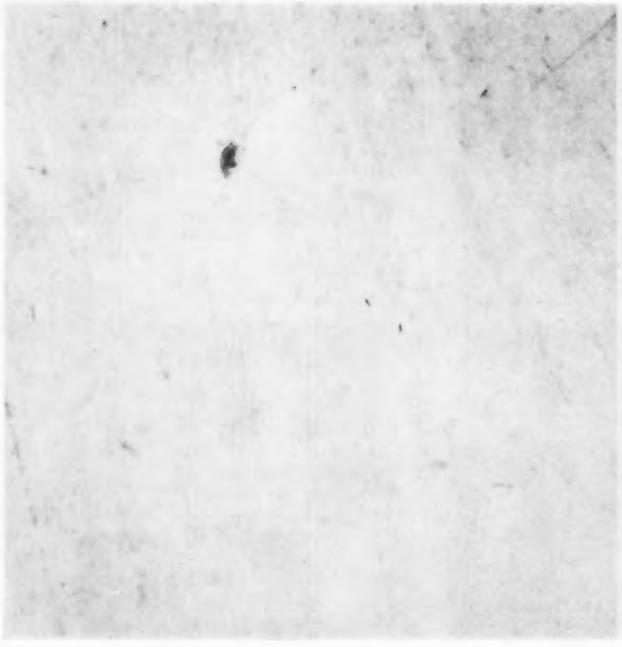

FIG. 4(*b*) PORTION OF FIG. 4(*a*); ×1000
(Vertical illumination.)

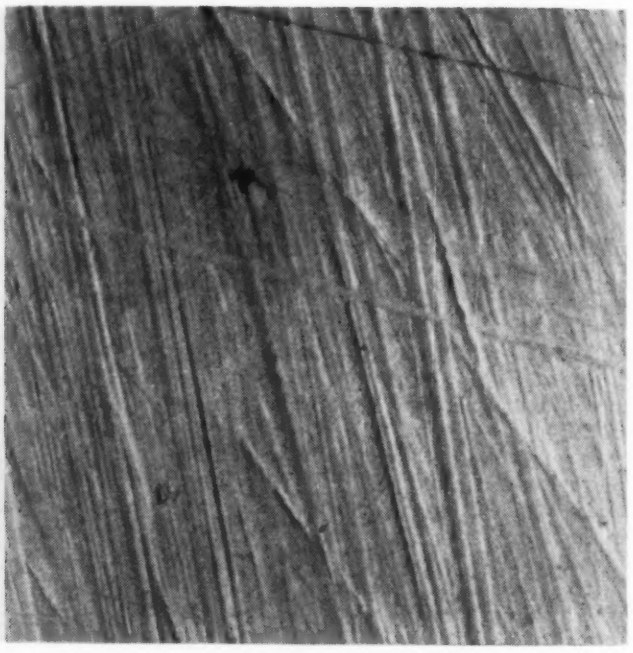

FIG. 4(*c*) SAME AREA AS FIG. 4(*b*); ×1000
(Oblique illumination.)

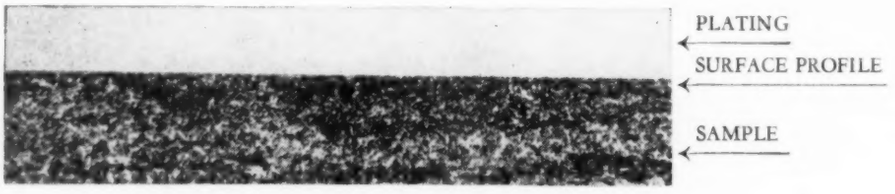

FIG. 4(*d*) PLATED CROSS SECTION OF FIG. 4(*a*); ×200

FIG. 4(*e*) PORTION OF FIG. 4(*d*); ×2500

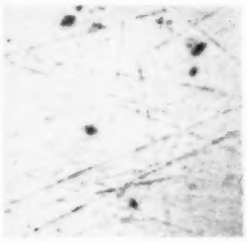

FIG. 5(*a*) SUPERFINISHED SURFACE; ×200
(1μ in. rms.)

FIG. 5(*b*) ONE AREA OF FIG. 5(*a*); ×3000
(Vertical illumination.)

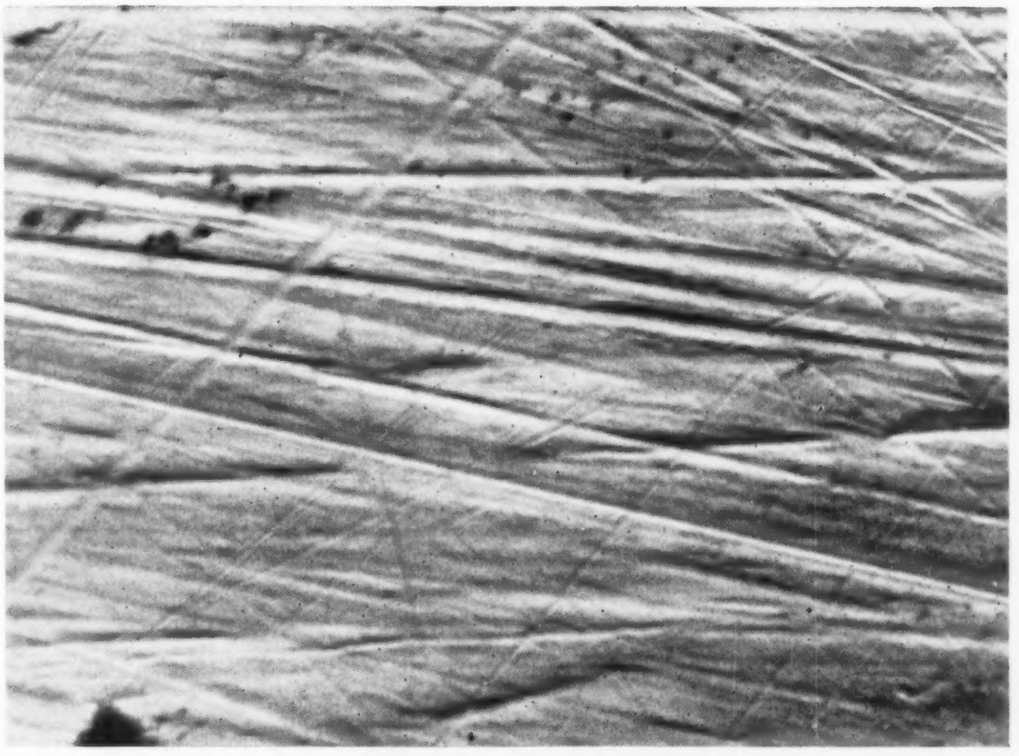

FIG. 5(*c*) SAME AREA AS THAT SHOWN IN FIG. 5(*b*); ×3000
(Oblique illumination.)

TABLE 6 SURFACES WITH "G" FINISH

Sample no. as prepared by shop A	B	C	D	E	F	Quality[a] of finish	Material	Machining data	Surface roughness, μ in. rms
..	..	...	1	..	..	Avg[b]	Steel	Rough grinding wheel Surface grinder?	350
..	..	...	2	..	..	Avg	Steel	Rough grinding wheel Surface grinder?	258
4	..	...	..	..	..	Sup.[c]	Brass	Rough grinding wheel	150
..	11	...	..	..	..	Just pass.[d]	Steel	Rough grinding wheel	110
5	..	...	..	..	..	Sup.	Steel	Rough grinding wheel	103
6	..	...	..	..	..	Sup.	Steel	Rough grinding wheel	102
..	..	...	..	5b	..	Avg	Steel	Hand-ground on universal grinder?	80
..	..	...	..	5a	..	Sup.	Steel	Ground on centers on universal grinder	67
..	12	...	..	..	..	Sup.	Steel	Centerless grinder	55
..	..	7ab	..	..	..	Avg	Hard steel	Surface grinder	45
..	..	10	..	..	..	Sup.	Bronze	Centerless grinder	45
..	..	7b	..	..	..	Avg	Hard steel	Surface grinder	30

[a] Opinion of shop which prepared the sample.
[b] Avg = average.
[c] Sup. = superior.
[d] Pass. = passable.
NOTE. These abbreviations apply to this and to Tables 7, 8, 9, and 10.

TABLE 7 SURFACES WITH "CF" FINISH

Sample no. as prepared by shop A	B	C	D	E	F	Quality[a] of finish	Material	Machining data	Surface roughness, μ in. rms
..	..	..	3c	..	..	Avg	Steel	Shave	450
5	..	..	...	..	..	Avg	Steel	Shape	400
6	..	..	...	..	..	Avg	Steel	Shape	400
..	..	..	...	..	8	Avg	Steel	Shave	350
..	..	..	3a	..	..	Avg	Steel	Mill	317
..	..	..	12	..	..	Avg	Steel	Turn	300
..	..	..	6c	..	..	Avg	Steel	Mill	275
..	..	..	6b	..	..	Avg	Steel	Shave	267
..	..	..	...	..	9	Avg	Steel	Shave	250
..	..	..	14	..	..	Avg	Steel	Turn	217
..	..	..	3b	..	..	Avg	Steel	Rough grinding wheel Surface grinder?	200
..	.	3a	...	..	..	Avg	Steel	Rough grinding wheel Disk grinder	175
.	..	..	...	3a	..	Avg	Steel	Turn	175
4	..	..	...	..	..	Avg	Brass	Shape	175
..	..	..	...	3b	..	Avg	Steel	Turn	158
..	..	..	6a	..	..	Avg	Steel	Rough grind Finish grind	83

[a] Opinion of shop which prepared sample

TABLE 9 SURFACES WITH "FF" FINISH

Sample no. as prepared by shop A	B	C	D	E	F	Quality[a] of finish	Material	Machining data	Surface roughness, μ in. rms
..	..	3b	...	..	..	Avg	Steel	Rough-grind—on surface Finish-grind—grinder	77
..	1	..	...	..	..	Just pass.	Steel	Turn	70
..	..	..	8a	..	..	Avg	Steel	Shave	62
..	2	..	...	..	..	Just pass.	Steel	Form	55
..	..	..	8b	..	..	Avg	Steel	Mill	53
..	..	3c	...	..	..	Avg	Steel	Rough-grind / Finish-grind } on surface grinder	50
..	..	8b	...	..	..	Avg	Steel	Turn Rough-grind / Finish-grind } on centerless grinder	50
..	..	..	10b	..	..	Avg	Steel	Shave	45
..	..	..	10a	..	..	Avg	Steel	Mill	40
..	..	..	11b	..	..	Avg	Steel	Turn	40
..	..	..	13b	..	..	Avg	Steel	Turn	40
..	..	..	...	..	1	Good	Steel	Mill File	35
4	..	..	...	..	..	Avg	Brass	Shave Polish—file and emery cloth	30
..	..	..	...	2b	..	Avg	Steel	Turn	28
..	..	..	...	2a	..	Avg	Steel	Turn	22
..	4	..	...	..	..	Sup.	Steel	Form	20
6	..	..	...	..	..	Avg	Steel	Shave Polish—file and emery cloth	19
..	..	..	...	..	2	Sup.	Steel	Mill File draw	18
5	..	..	...	..	..	Avg	Steel	Shave Polish—file and emery cloth	16
..	3	..	...	..	..	Sup.	Steel	Turn	14
..	..	2	...	..	..	Sup.	Steel	Turn	12

[a] Opinion of shop which prepared the sample.

TABLE 8 SURFACES WITH "F" FINISH

Sample no. as prepared by shop A	B	C	D	E	F	Quality[a] of finish	Material	Machining data	Surface Roughness, μ in. rms
..	5	..	...	..	..	Just pass.	Steel	Turn	250
..	..	1b	...	..	..	Avg	Steel	Turn	225
..	..	..	7a	..	..	Avg	Steel	Shave	225
..	..	..	9b	..	..	Avg	Steel	Mill	225
..	..	..	7b	..	..	Avg	Steel	Mill	208
..	..	..	9a	..	..	Avg	Steel	Shave	200
..	6	..	...	..	..	Just pass.	Steel	Form	175
..	..	1a	...	..	..	Avg	Steel	Turn	175
..	..	..	11a	..	..	Avg	Steel	Turn	167
..	..	..	...	..	3	Avg[b]	Steel	Shave file	158
..	..	..	13a	..	..	Avg	Steel	Turn	150
..	..	1d	...	..	..	Avg	Steel	Turn	150
4	..	..	...	..	..	Avg	Brass	Shave	100
..	..	4b	...	..	..	Avg	Steel	Mill	87
5	..	..	...	..	..	Avg	Steel	Shave	80
..	..	1c	...	..	..	Avg	Steel	Turn	72
..	..	..	...	1a	..	Avg	Steel	Turn	68
6	..	..	...	..	..	Avg	Steel	Shave	63
..	7	..	...	..	..	Sup.	Steel	Turn	55
..	..	..	...	1b	..	Avg	Steel	Turn	45
..	..	..	...	..	4	Avg[b]	Steel	Mill	45
..	8	..	...	..	..	Sup.	Steel	Form	40

[a] Opinion of shop which prepared sample.
[b] Shop F states that both 3 and 4 represent good work, but that 4 is preferable.

in Figs. 4(*d*) and 4(*e*). Fig. 4(*b*) (×1000), which illustrates one of the smoother areas of Fig. 4(*a*), was photographed with vertical illumination. Fig. 4(*c*) (×1000) illustrates the same area when photographed with oblique illumination. This photomicrograph, made with filtered light having a wave length of about 4500A and an objective having 0.95.N.A., shows, at 1000 diam, minimum irregularities which are originally of the order of 0.000005 in. wide,[6] whereas for the same surface, the tracer-point instrument recorded irregularities of the order of 0.000003 in. (3 μ in. rms) deep. The plated profile view of the surface, Fig. 4(*e*), suggests neither depth nor width of irregularity, and yet the photomicrograph was made under conditions (filtered light with a wave length of about 4500A and an objective having 1.4 N.A.) capable of revealing, at 2500 diam, minimum irregularities which are originally of the order of 0.000006 in. wide.[6]

Fig. 5 presents an additional illustration of a superfinished surface as revealed by the microscope. Fig. 5(*b*) (×3000) was photographed with vertical illumination. Fig. 5(*c*) (×3000) illustrates the same area when photographed with oblique illumination. This photomicrograph, made with filtered light having a wave length of about 4500A and an objective having 1.6 N.A., shows, at 3000 diam, minimum irregularities which

[6] See Table 4.

TABLE 10 SURFACES WITH "FG" FINISH

Sample no. as prepared by shop A	B	C	D	E	F	Quality[a] of finish	Material	Machining data	Surface roughness, μ in. rms
..	..	...	..	..	5	Avg	Steel	Finish-grind, rotary surface grinder	70
..	..	...	5	..	..	Avg	Steel	Rough-grind, Finish-grind } surface grinder?	58
..	..	...	4	..	..	Avg	Steel	Rough-grind, Finish-grind } surface grinder?	54.3
..	..	...	..	..	6	Good	Steel	Finish-grind, horizontal surface grinder	35
..	..	5a	..	..	..	Avg	Steel, hard	Rough-grind, external grinder	30
4	..	...	..	..	..	Avg	Brass	Finish-grind, horizontal surface grinder	20
..	..	4a	..	..	..	Avg	Steel	Rough-grind, Finish-grind } centerless grinder	20
..	..	6a	..	..	..	....	Steel, hard	Rough-grind, external grinder	18
..	..	7c	..	..	..	Avg	Steel, hard	Rough-grind, Finish-grind } surface grinder	15
..	..	9a	..	..	..	Avg	Steel, carbon	Finish-grind, centerless grinder	15
..	..	10a	..	..	..	Sup.	Bronze	Turn Finish-grind, circular surface grinder	15
..	..	...	..	..	7	Avg	Steel	Finish-grind, horizontal surface grinder Lap	12
..	..	9b	..	..	..	Sup.	Steel, carbon	Buffing-wheel, no. 220 emery	10
..	..	...	..	4b	..	Avg	Steel	Rough-grind, Finish-grind } universal grinder	10
..	..	...	..	4a	..	Avg	Steel, hard	Rough-grind, Finish-grind } universal grinder	8
..	..	5b	..	..	..	Avg	Steel, hard	Rough-grind, Finish-grind } external grinder	6.7
..	9	...	..	..	..	Just pass.	Steel	Finish-grind, plain grinder	6.6
..	..	8a	..	..	..	Avg	Steel N	Turn Rough-grind Finish-grind, internal grinder	5.5
5	..	...	..	..	..	Avg	Steel	Finish-grind, horizontal surface grinder	4
6	..	...	..	..	..	Avg	Steel	Finish-grind, horizontal surface grinder	4
..	..	6b	..	..	..	Sup.	Steel, hard	Rough-grind, Finish-grind } external grinder	3.8
2	..	...	..	..	..	Sup.	Monel	Finish-grind Lap, lapping stones in honing machine	3.5
3	..	...	..	..	..	Sup.	Monel	Finish-grind Lap, lapping stones in honing machine	3.5
..	..	6c	..	..	..	Sup.	Steel, hard	Rough-grind, Finish-grind } external grinder	3.2
1	..	...	..	..	..	Sup.	Monel	Rough-grind Finish-grind Lap, lapping stones in honing machine	3

[a] Opinion of shop which prepared the sample.

TABLE 11 SURFACE-FINISH SAMPLES SUBMITTED FOR DEVELOPMENT OF ORDANCE FINISH STANDARDS

Sample no.[a]	Finish[b]	Material	Machining data	Tool data	Operations necessary to secure finish
A-1 Interior of cylinder	FG	Monel	Feed: 40 fpm Oleic acid, turpentine, kerosene	Lapping head-micromatic B 600H stones	Rough-grind Finish-grind Lap
A-2 Interior of cylinder	FG	Monel	Feed: 40 fpm Oleic acid, turpentine, kerosene	Lapping head-micromatic B 600H stones	Finish-grind Lap
A-3 Piston	FG	2340 steel	Feed: 40 fpm Oleic acid, turpentine, kerosene	Lapping head-micromatic B 600H stones	Finish-grind Lap
A-4 Sample	G or CG	Brass	Feed: hand-grind Speed: 5500 sfpm	Grinding wheel, Norton 3824-M8BE	Rough-grind
A-4 Sample	CF	Brass	Feed: 0.051 in. Speed: 65 strokes per min Cutting fluid: dry	H.S. steel Rex AA Radius 1/16 in. Rake negative Relief 10°	Shape
A-4 Sample	F	Brass	Feed: 0.015 in. Speed: 130 strokes per min Cutting fluid: dry	H.S. steel Rex AA Radius 1/16 in. Rake negative Relief 10°	Shave
A-4 Sample	FF	Brass	Feed: 0.008 in. Speed: 130 strokes per min Cutting fluid: dry	H.S. steel Rex AA Radius 1/4 in. Rake negative Relief 10°	Shave Polish
A-4 Sample	FG	Brass	Feed: 0.020 in. Speed: 5500 sfpm Cutting fluid: dry	Grinding wheel, Norton 3824-M8BE	Finish-grind
A-5 Sample	G or CG	1045 steel	Feed: hand-grind Speed: 5500 sfpm Cutting fluid: dry	Grinding wheel, Norton 3824-M8BE	Rough-grind
A-5 Sample	CF	1045 steel	Feed: 0.042 in. Speed: 45 strokes per min Cutting fluid: lard oil	H.S. steel Rex AA Radius 1/8 in. Rake 12° Relief 6°	Shave
A-5 Sample	F	1045 steel	Feed: 0.012 in. Speed: 92 strokes per min Cutting fluid: lard oil	H.S. steel Rex AA Radius 1/4 in. Rake 12° Relief 6°	Shave
A-5 Sample	FF	1045 steel	Feed: 0.005 in. Speed: 92 strokes per min Cutting fluid: lard oil	H.S. steel Rex AA Radius 1/4 in. Rake 12° Relief 6°	Shave
A-5 Sample	FG	1045 steel	Feed: 0.020 in. Speed: 5500 sfpm Cutting fluid: dry	Grinding wheel, Norton 3890-P7BE	Finish-grind
A-6 Sample	G or CG	2330 steel	Feed: hand-grind Speed: 5500 sfpm	Grinding wheel, Norton 3824-M8BE	Rough-grind
A-6 Sample	CF	2330 steel	Feed: 0.042 in. Speed: 45 strokes per min Cutting fluid: lard oil	H.S. steel Rex AA Radius 1/8 in. Rake 12° Relief 6°	Shape
A-6 Sample	F	2330 steel	Feed: 0.012 in. Speed: 92 strokes per min Cutting fluid: lard oil	H.S. steel Rex AA Radius 1/4 in. Rake 12° Relief 6°	Shave
A-6 Sample	FF	2330 steel	Feed: 0.005 in. Speed: 92 strokes per min Cutting fluid: lard oil	H.S. steel Rex AA Radius 1/4 in. Rake 12° Relief 6°	Shave Polish
A-6 Sample	FG	2330 steel	Feed: 0.020 in. Speed: 5500 sfpm Cutting fluid: dry	Grinding wheel, Norton 3890-P7BE	Finish-grind

[a] Prefixed letter indicates shop which submitted work, e.g., Shop A-B-C-D-E-F.
[b] This finish does not necessarily apply to the latest revision of drawings for these components.

(Continued on page 713)

(*Continued from page 712*)

Sample no.[a]	Finish[b]	Material	Machining data	Tool data	Operations necessary to secure finish
B-1 Cylindrical sample finished in toolroom	FF	X1314 steel	Feed: 0.0025 in. Speed: 150 fpm Cutting fluid: cutting oil	Tool bit Rex AA H.S. Radius 0.062 Rake 14° Relief 10°	Turn
B-2 Cylindrical sample finished in toolroom	FF	X1314 steel	Feed: 0.0025 in. Speed: 85 fpm Cutting fluid: cutting oil	Tool bit Rex AA Rake 10° Relief 8°	Form
B-3 Cylindrical sample finished in toolroom	FF	X1314 steel	Feed: 0.0025 in. Speed: 150 fpm Cutting fluid: cutting oil	Tool bit Rex AA H.S. Radius 0.062 Rake 14° Relief 10°	Draw file Turn
B-4 Cylindrical sample finished in toolroom	FF	X1314 steel	Feed: hand Speed: 85 fpm Cutting fluid: cutting oil	Tool bit Rex AA Rake 10° Relief 8°	Draw file Form
B-5 Cylindrical sample finished in toolroom	F	X1314 steel	Feed: 0.026 in. Speed: 190 fpm Cutting fluid: cutting oil	Tool bit Rex AA Radius 0.062 Rake 12° Relief 10°	Turn
B-6 Cylindrical sample finished in toolroom	F	X1314 steel	Feed: 0.0025 in. Speed: 140 fpm Cutting fluid: cutting oil	Rex AA Tool Bit Rake 10° Relief 8°	Form
B-7 Cylindrical sample finished in toolroom	F	X1314 steel	Feed: 0.0025 in. Speed: 140 fpm Cutting fluid: cutting oil	Rex AA tool bit Radius 0.062 Rake 14° Relief 10°	Turn
B-8 Cylindrical sample finished in toolroom	F	X1314 steel	Feed: 0.0025 in. Speed: 125 fpm Cutting fluid: cutting oil	Rex AA tool bit Rake 10° Relief 8°	Form
B-9 Cylindrical sample finished in toolroom	FG	X1314 steel	Feed: 0.005 in. Speed: Table 6 lpm Cutting fluid: water-soluble	B&S plain grinder 1960K5 wheel	Finish-grind
B-10 Cylindrical sample finished in toolroom	FG	X1314 steel H.T.: hardened, Rock. 63 C	Feed: 0.0005 in. Speed: Table 6 lpm Cutting fluid: water-soluble	B&S plain grinder 1960K5	Polish Finish-grind Lap
B-11 Cylindrical sample finished in toolroom	G	X1314 steel	Feed: 0.001 in. Speed: Table 58.34 lpm Cutting fluid: water-soluble	No. 1 B&S universal grinder; Aloxite wheel 401-N-200	Rough-grind
B-12 Cylindrical sample finished in toolroom	G	X1314 steel	Cutting fluid: water-soluble	No. 2 Cincinnati centerless grinder; Aloxite wheel 40-0-30	Rough-grind
C-1a Pinion (blank)	F	4140 steel H.T.: hot rolled, annealed	Feed: 0.002 in. Speed: 170 rpm Cutting fluid: sulphurized oil	Form tool on turret lathe Rex AA Relief: standard circular form tool	Turn
C-1b Pinion (blank)	F	4140 steel H.T.: hot rolled, annealed	Feed: 0.002 in. Speed: 170 rpm Cutting fluid: sulphurized oil	Single point turning tool, turret lathe Rex AA: tools ground freehand	Turn
C-1c Pinion (blank)	F	4140 steel H.T.: hot rolled, annealed	Feed: 0.002 in. Speed: 170 rpm Cutting fluid: sulphurized oil	Roller box mill, single point turning with roller support; tool bits ground freehand	Turn
C-1d Pinion (blank)	F	4140 steel H.T.: hot rolled, annealed	Feed: 0.002 in. Speed: 170 rpm Cutting fluid: sulphurized oil	Single point turning—Rex AA; tool bits ground freehand	Turn
C-2 Pin	FF dwg. req. F	1315 steel H.T.: cold-finish Rock. C-27	Feed: 0.003 in. Speed: 550 rpm Cutting fluid: sulphurized oil	Roller box mill single point with roller support; tool bits ground freehand	Turn
C-3a Suspension plate	CF	X4340 steel, heat-treated	Feed: by hand Speed: varies widely	Disk grinder using 80 grit Al_2O_3 wheel	Rough-grind

[a] Prefixed letter indicates shop which submitted work, e.g., Shop A-B-C-D-E-F.
[b] This finish does not necessarily apply to the latest revision of drawings for these components.

(*Continued on page 714*)

(*Continued from page 713*)

Sample no.[a]	Finish[b]	Material	Machining data	Tool data	Operations necessary to secure finish
C-3b Suspension plate	FF dwg. req. FF	X4340 steel, not heat-treated	Cutting fluid: soluble oil Speed: about 5500 surface fpm	Thompson surface grinder: 3746J-Norton (Si C)	Rough-grind Finish-grind
C-3c Suspension plate	FF dwg. req.	X4340 steel, not heat-treated	Cutting fluid: soluble oil Speed: about 5500 surface fpm	Thompson surface grinder; 3746J-Norton (Si C)	Rough-grind
C-4a Pintle (taper portion)	FG dwg. req. FF on taper portion	4140 steel, hot rolled	Cutting fluid: soluble oil Speed: work revolves at 29 rpm; face of wheel about 7200 fpm	Centerless grinder; 60K5BE Norton	Rough-grind Finish-grind
C-4b Pintle	F dwg. req. FF	4140 steel, hot rolled	Cutting fluid: soluble oil Speed: 7-in-diam cutters run at 24 rpm; roughing feed $^3/_4$ in. per min; finishing speed $1^1/_{16}$ in. per min	Inserted tooth interlocking cutters; apex at periphery: Rake 5° Relief 5°	Mill
C-5a Sample specimen, represents finish used on gages	FG	Drill rod: approx. 1 per cent carbon, hardened to about 60–63 Rock. C	Speed: 6000 sfpm Cutting fluid: soluble oil	External grinder, 100N-Norton	Rough-grind
C-5b Sample specimen, represents finish used on gages	FG	Drill rod: approx. 1 per cent carbon, hardened to about 60–63 Rock. C	Speed: 6000 sfpm Cutting fluid: soluble oil	External grinder, 100N-Norton	Rough-grind Finish-grind
C-6a Sample specimen, represents finish used on gages	FG	High-speed tool steel, hardened to approx. 63–65 Rock. C	Speed: 6000 sfpm Cutting fluid: soluble oil	External grinder, 100N-Norton	Rough-grind
C-6b Sample specimen, represents finish used on gages	FG	High-speed tool steel, hardened to approx. 63–65 Rock. C	Speed: 60000 sfpm Cutting fluid: soluble oil	External grinder, 100N-Norton	Rough-grind Finish-grind
C-6c Sample specimen, represents finish used on gages	FG	High-speed tool steel, hardened to approx. 63–65 Rock. C	Speed: 6000 sfpm Cutting fluid: soluble oil	External grinder, 100N-Norton	Rough-grind Finish-grind
C-7a Sample specimen, represents finish used on gages	G	Flat stock, equal to 1095 steel, hardened to approx. 60 Rock. C	Speed: 6000 sfpm	Surface grinder, 3824J8BE-Norton	Round-grind
C-7b Sample specimen, represents finish used on gages	G	Flat stock, equal to 1095 steel, hardened to approx. 60 Rock. C	Speed: 6000 sfpm	Surface grinder, 3824J8BE-Norton	Rough-grind
C-7c Sample specimen, represents finish used on gages	FG	Flat stock, equal to 1095 steel, hardened to approx. 60 Rock. C	Speed: 6000 sfpm	Surface grinder, 3824J8BE-Norton	Rough-grind Finish-grind
C-7d Sample specimen, represents finish used on gages	Lap	Flat stock, equal to 1095 steel, hardened to approx. 60 Rock. C	Speed: 6000 sfpm	Surface grinder, 3824J8BE-Norton	Rough-grind Finish-grind Lap
C-8a Axle bushing	FG dwg. req. F	Nitralloy, grade H, nitrided to Rock. A-80	Cutting fluid: soluble oil Speed: Rotates at 600 rpm; abrasive speed, 8000 fpm	Internal grinder, 3860K5BE-Norton	Turn Rough-grind Finish-grind
C-8b	FF dwg. req. F	Nitralloy, grade H	Cutting fluid: soluble oil Speed: Piece makes about 24 rpm; abrasive speed, 8500 fpm	Centerless grinder, 3860K5BE-Norton	Turn Rough-grind Finish-grind
C-9a Plunger latch (side)	FG	Carbon steel 46-S-6 H.T. carburized before grinding and polishing	Cutting fluid: soluble oil Speed: Work, 36 rpm; face of wheel moves at about 7200 fpm	Centerless grinder, 60K5BE-Norton	Finish-grind Dwg. calls for grind and polish
C-9b Plunger latch (end)	FG	Carbon steel 46-S-6 H.T. carburized before grinding and polishing	Buff about 1600 rpm 12-in-diam buff	Buffing wheel with 220 grit emery, Walrus-hide buff	Finish-grind
C-10a Valve	FG dwg. req. FG	High-tensile bronze; heat-treated to 196 Brinell	Cutting fluid: soluble oil Table speed: 600 rpm Spindle speed: 1200 rpm	Heald circular table surface grinder, 3750K-Norton (Si C)	Turn Rough-grind Finish-grind

[a] Prefixed letter indicates shop which submitted work, e.g., Shop A-B-C-D-E-F.
[b] This finish does not necessarily apply to the latest revision of drawings for these components.

(*Continued on page 715*)

(*Continued from page 715*)

Sample no.[a]	Finish[b]	Material	Machining data	Tool data	Operations necessary to secure finish
C-10b Valve (outer surface)	G	High-tensile bronze; heat-treated to 196 Brinell	Cutting fluid: soluble oil Abrasive speed about 5600 fpm	Centerless grinder, 60-grit Si C wheel	Turn Finish-grind
C-10c (Small hole at buffer rod nut end) Valve	FG dwg. req. FF	High-tensile bronze; heat-treated to 196 Brinell	Cutting fluid: soluble oil Abrasive speed about 3000 fpm	Internal grinder 3760J-Norton (Si C)	Turn Finish-grind
D-1 Specimen	G	3140 steel	.....	Grinding wheel, Norton wheel	Rough-grind Finish-grind
D-2 Specimen	G	5160 steel	.....	Grinding wheel, Norton wheel	Rough-grind Finish-grind
D-3 Specimen	CF	6150 steel	Feed: 2.7 fpm Speed: 63 Cutting fluid: cutting oil	Mill	Mill
D-3 Specimen	CF	6150 steel	.....	Carborundum wheel, med. fine	Rough-grind
D-3 Specimen	CF	6150 steel	Feed: 3 notches Speed: 2	.....	Shave
D-4 Specimen	FG	6150 steel	.....	Carborundum wheel	Rough-grind Finish-grind
D-5 Specimen	FG	3140 steel	.....	Carborundum wheel	Rough-grind Finish-grind
D-6 Specimen	CF	3140 steel	.....	Norton wheel, coarse	Rough-grind Finish-grind
D-6 Specimen	CF	3140 steel	Feed: 3 notches Speed: 2	.....	Shave
D-6 Specimen	CF	3140 steel	Feed: 2.7 fpm Speed: 63 Cutting fluid: oil	.....	Mill
D-7 Specimen	F	6150 steel	Feed: 3 notches Speed: 2	.....	Shave
D-7 Specimen	F	6150 steel	Feed: 1.3 Speed: 50 Cutting fluid: cutting oil	3-in. spiral	Mill
D-8 Specimen	FF	6150 steel	Feed: fine Speed: 50	.....	Shave
D-8 Specimen	FF	6150 steel	Feed: $^5/_8$ in. per min Speed: 60 rpm Cutting fluid: oil	$2^1/_2$-in. spiral surface mill, Armory Mfg.	Mill
D-9 Specimen	F	3140 steel	Feed: 1 notch Speed: 2	.....	Shave
D-9 Specimen	F	3140 steel	Feed: 1.3 Speed: 50 Cutting fluid: cutting oil	.....	Mill
D-10 Specimen	FF	3140 steel	Feed: $^5/_8$ in. per min Speed: 60 rpm Cutting fluid: cutting oil	$2^1/_2$-in. spiral surface mill, Armory Mfg.	Mill
D-10 Specimen	FF	3140 steel	Feed: $^5/_8$ in. fine Speed: 50	.....	Shave
D-11 Specimen	FF	6150 steel	Feed: 0.0055 in. Speed: 240 rpm	Radius at point $^1/_{16}$ in.	Turn
D-11 Specimen	F	6150 steel	Feed: 0.007 in. Speed: 180 rpm	Lathe tool	Turn
D-12 Specimen	CF	6150 steel	Feed: 0.011 in. Speed: 45 rpm	Radius at point $^1/_{16}$ in.	Turn

[a] Prefixed letter indicates shop which submitted work, e.g., Shop A-B-C-D-E-F.
[b] This finish does not necessarily apply to the latest revision of drawings for these components.

(*Continued on page 716*)

(*Continued from page 715*)

Sample no.[a]	Finish[b]	Material	Machining data	Tool data	Operations necessary to secure finish
D-13 Specimen	FF	3140 steel	Feed: 0.0055 in. Speed: 240 rpm	Lathe tool	....
D-13 Specimen	F	3140 steel	Feed: 0.007 in. Speed: 180 rpm	Lathe tool	....
D-14 Specimen	CF	3140 steel	Feed: 0.011 in. Speed: 45 rpm	Radius at point 1/16 in.	Turn
E-1 Sample only from lathe shop	F	1020 steel	.....	H.S. steel	Turn
E-2 Sample only from lathe shop	FF	1020 steel	.....	H.S. steel	Turn
E-3 Sample only	CF	1020 steel	.....	H.S. steel	Turn
E-4 Sample only from tool room	FG	1020 steel H.T.: one sample hardened; one sample soft	.....	Universal grinder	Rough-grind Finish-grind
E-5 Sample only from tool room	G	.....	.....	.....	1 sample hand ground 1 sample ground on centers on universal grind machine Rough-grind
F-1 Sample block, surplus stock	FF-1	Steel forging, cold-worked	Cutting fluid: Solvac	L.H. spiral end mill Rake: standard Relief: standard	Mill File
F-2 Sample block, surplus stock	FF-2	Steel forging, cold-worked	Cutting fluid: Solvac	L.H. spiral end mill Rake: standard Relief: standard	Mill File draw
F-3 Sample block, sample stock	F-2	Steel casting	.....	Straight-nose planer tool, Ludlum (xx) Radius: 0.01 Rake: 7° Relief: 3°	Shave File
F-4 Sample block, surplus stock	F-2	Steel forging, cold-worked	Cutting fluid: Solvac	End mill L.H. spiral cut end mill Rake: standard Relief: standard	Mill
F-5 Sample block, sample stock	FG-1	Steel casting	Cutting fluid: Solvac	Rotary surface grinder, Heald Rake: standard Relief: standard	Finish-grind
F-6 Sample block, surplus stock	FG-2	Steel forging, cold-worked	.....	Horizontal surface grinder; abrasive no. 3	Finish-grind
F-7 Sample block, surplus stock	FG-3	Steel forging, cold-worked	.....	Horizontal surface grinder; abrasive no. 3	Finish-grind Lap
F-8 Sample block, surplus stock	CF-1	Steel casting	Feed: 0.02	H.S. tool bits, Ludlum (xx) Radius: 0.02 Rake: 7° Relief: 3° top face	Shave
F-9 Sample block	CF-2	Steel casting	Feed: 0.02	H.S. tool bit, Ludlum (xx) Radius: 0.02 Rake: 7° Relief: 3°	Shave
F-10 Collar chain	G	Drop forging, 1035 steel Heat-treatment: Brin. 200–220	.....	(Double wheel) spindle bench grinder	Rough-grind

[a] Prefixed letter indicates shop which submitted work, e.g., Shop A-B-C-D-E-F.
[b] This finish does not necessarily apply to the latest revision of drawings for these components.

are originally of the order of 0.000003 in. wide,[6] whereas for the same surface the tracer-point instrument recorded irregularities of the order of 0.000001 in. (1 μ in. rms) deep.

Method 1(*c*), which employs an instrument to measure and to express surface finish as a number, is the most practical one for evaluating shop finishes. It was used to obtain the data needed for the development of standards for ordnance finishes.

Data Obtained by Measuring Finish of Samples Submitted for Development of Standards. The degree of finish on three different areas of each sample secured for this study was measured by a tracer-point instrument as previously stated. The average of the three measurements is recorded in Table 5, which summarizes the finish values for all the samples submitted by six different ordnance establishments.

Tables 6 to 10, inclusive, present the values of Table 5 rearranged according to class of finish, in decreasing values of finish. Tables 5 to 10 indicate that different shops do indeed have different interpretations of the finish symbols used on drawings. In many cases the very low values for any one symbol must be discounted because the shops concerned listed them as superior finishes. Furthermore, it must be emphasized that expediency, rather than careful selection, governed the obtaining of samples for the present job.

Formulation of Standards for Ordnance Finishes. The data in Table 5 were forwarded to the Surface Finish Committee for study. The committee deliberated on the values for the symbols F, FF, and FG only. It chose the following values as ones which should be typical and which would conform to the number series of the proposed American Standard:

F	FF	FG
250	32	16
175[a]	..	..

[a] This value does not conform to the number series of the propose d American Standard.

Tentative reference samples having finishes corresponding to these figures were prepared in an ordnance shop. These samples were then compared visually and tactually with production surfaces of artillery carriages manufactured in the same establishment. The comparisons, which were made by members of the Inspection Department and by members of the committee, were agreeably favorable. In one case the test was reversed by having a workman examine the reference samples and name the finish in terms of the drawing symbol. He called each one accurately.

Later, additional reference samples having the following values were prepared:

F	Lap
125	8
63	..

These were taken by the committee to a number of industrial establishments throughout two different Ordnance Districts where various types of matériel are being manufactured. Comparisons were again made between the finishes of production surfaces and the reference samples. On the basis of the information gained in this manner, the committee selected the series of numbers listed in Table 2, as those which most accurately represent the finish symbols currently used on drawings.

STANDARDS OF ORDNANCE FINISHES

Having established definite values for the degrees of finish now represented by the symbols F, FF, and FG on ordnance drawings (Table 2), it was possible to devise a set of reference samples which are to serve as Standards of Ordnance Finishes.

The use of reference samples as a means of inspecting finishes has been practiced to some extent in industry. Over a decade ago Harrison (1) described those used by the Cincinnati Grinders, Inc., namely, 1-in-diam cylindrical plugs ground to the various progressive standards of finish. Deale (2) described those used by the Norton Company. The latter included three degrees of grinding finishes, planing finishes, face-milling finishes, side-milling finishes, and a polished finish.

Many factors were considered before final selection of a set of reference samples to be standards. Among these were the effect of comparing cylindrical with flat surfaces and vice versa; the effect of comparing different kinds of metals such as effects of color; and finally, the effect of comparing surfaces cut by different machine tools or grinding wheels. In the consideration of these points, some valuable assistance was given by several members of the General Electric Company who explained the experience they had had with reference samples over a period of years.

In order to give the inspector a simple gage, it was finally decided to reproduce the desired finishes, listed in Table 2, on a series of flat blocks, similar to those used by the General Electric Company. Each block corresponds to one of the values given in the table. In the case of the four roughest blocks, the block itself consists of four pieces each produced by a different machining operation. Two of the smoother blocks consist of two pieces, each prepared in a different manner. Thus there are 21 sample pieces representing 7 degrees of surface finish.

The samples are made of rustless iron and are enclosed in a convenient metal box $5^3/_4 \times 8^3/_4 \times {}^1/_2$ in. Their arrangement within the box is shown in Fig. 1. As explained on the name plate, the standards are to be used for inspecting ordnance finishes by visual or tactual comparison. Five sets of these reference blocks are to be retained at Watertown Arsenal and will become the master standards for use in future calibration.

It is expected that the use of the reference blocks will lead primarily to a uniform interpretation of existing surface-finish symbols on drawings for all types of Army ordnance matériel and, ultimately, to the development of more perfect standards for Army ordnance finishes.

Five master sets of these Standards of Ordnance Finishes are being retained for future calibration and standardization purposes.

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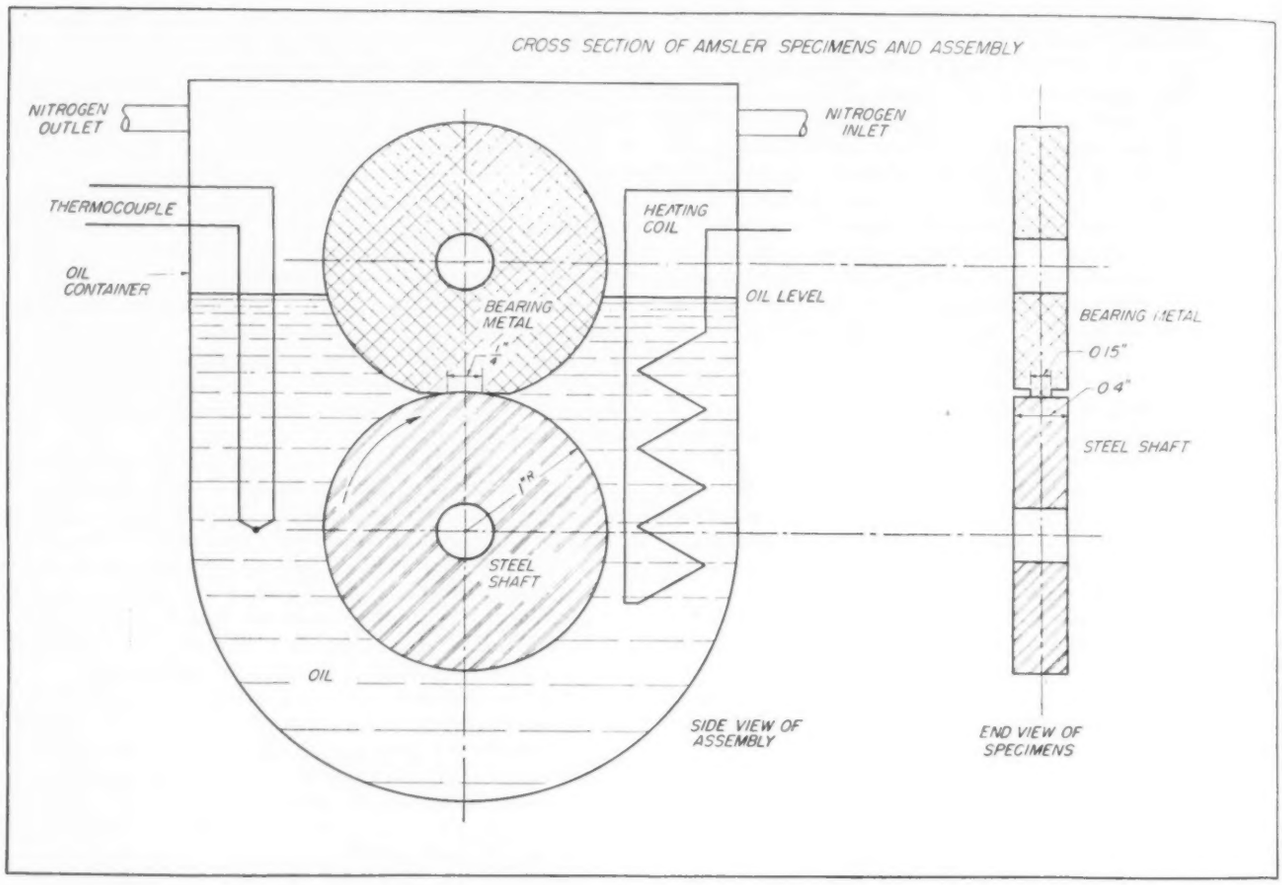

FIG. 1 SCHEMATIC DIAGRAM OF BEARING AND SHAFT ASSEMBLED FOR TEST

SURFACE FINISH *of* JOURNALS

As Affecting Friction, Wearing-In, and Seizure of Bearings

By R. W. DAYTON,[1] H. R. NELSON,[1] and L. H. MILLIGAN[2]

THE final finish put on journal surfaces in manufacture is vitally important to their behavior in severe service, particularly during the critical "breaking-in" period. Because finish is so important, one would expect to find some unanimity of opinion concerning the desirable type of surface finish for specific applications. On the contrary, one finds in the literature the statements that smooth surfaces are always best, Wallace (1),[3] Swigert (2), that interrupted surfaces are less likely to score, Teetor (3), that pitted journal surfaces cause less bearing fatigue, Allen (4), and that sandblasted surfaces are less prone to galling, Schurig (5). A reader of such discordant views finds it difficult to evaluate the situation and must decide that more information is necessary for clarification. It is hoped that this paper will supply some of the necessary data.

The information presented was obtained as a part of a more extensive investigation on the major phases of the performance of abrasively finished surfaces. This paper deals only with the effect of shaft finish on the seizure of plain bearings. Such seizure, which occurs when hydrodynamic lubrication is not maintained, is a serious problem in heavily loaded high-speed bearings, such as those in the master rod of radial aircraft engines. It is known that surface finish has an important effect on the seizure of such bearings.

As a sleeve bearing is loaded under conditions of hydrodynamic lubrication, the coefficient of friction decreases and the oil film becomes thinner. When the oil film is reduced in thickness sufficiently, the high points of the shaft touch those of the bearing. Then the coefficient of friction becomes much greater, large amounts of heat are generated in a high-speed bearing, and the bearing seizes. Galling of the mating surfaces may or may not occur at the time of seizure.

[1] Battelle Memorial Institute, Columbus, Ohio.
[2] Norton Company, Worcester, Mass.
[3] Numbers in parentheses refer to the Bibliography at the end of the paper.

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This frictional seizure or sticking is only one type of bearing failure. Mechanical fatigue or chemical corrosion may also cause trouble but neither is included in the present discussion and study.

Our work is concerned with the load-carrying capacity of bearings in which a journal is operated against an antifriction metal in the field of thin-film lubrication. We have studied different surface finishes on the journal as produced by the different commercial operations of grinding, sandpapering, lapping, etc. Recently published experimental work, Burwell (6), shows that the smoother the surface, the greater the load that may be carried without seizure, but in that work no surfaces of equal smoothness prepared by different methods were tested. Since it was likely that the "type" as well as the "smoothness" of a surface would influence seizure, the present investigation was extended to the study of surfaces prepared by various commercial methods. More than one degree of smoothness of each type of surface was investigated. The roughness of the surfaces fell in the range of 1.0 to 10 rms microinches as read on a profilometer. It is apparent, therefore, that all of the surfaces studied fall in the class of fine surface finishes.

PREPARATION OF SPECIMENS

Data are reported for steel surfaces finished by grinding, sandpapering, loose-abrasive lapping, and "hyprolapping."[4] Some data were also obtained on superfinished surfaces, which gave results falling in the middle range of friction and seizure characteristics reported, but these data have not been included because it was not certain that the specimens were representative of the best surfaces to be obtained by superfinishing methods.

[4] The "hyprolap" machine uses two bonded abrasive lapping wheels rotating in opposite directions about a vertical axis with the work mounted between the wheels in a work holder. Pressure is applied hydraulically and decreases as the lapping operation progresses and the upper lap comes down to a preadjusted stop.

The specimens were made of S.A.E. 6150 spindle steel hardened to 42 Rockwell C. The composition of this steel is given in Table 1. Metallographic examination showed the microstructure to be normal for heat-treated steel of this hardness.

The shaft specimens were prepared by Norton Company by commercial methods on commercial machines and are representative of typical journal finishes in industrial use. No efforts were made to prepare either extremely smooth or extremely rough surfaces. Every effort was made, however, to control the conditions of preparation so that reproducible surfaces could be obtained. The description of the various finishing operations is given in Table 2. It is apparent that the terms "fine," "medium," and "rough" are purely relative descriptive terms within the class of fine finishes being considered.

TABLE 1 ANALYSIS OF S.A.E. 6150 SPINDLE STEEL

C.....0.48 per cent	S.....0.016 per cent
Mn.....0.64 per cent	Cr.....0.98 per cent
P.....0.013 per cent	V.....0.19 per cent
Hardness.....42 Rockwell C	

METHOD OF TESTING

The seizure tests were made on an Amsler machine, which has been found to give results in accord with service data if a proper test procedure is followed, Dayton (7). A desirable feature of this machine is that the friction rises smoothly and steadily with increasing load in the region of imminent seizure. The test may be run indefinitely under conditions of incipient seizure, and the changes of seizure resistance with time of wearing-in can be studied.

The Amsler machine (7) is well known and does not need description. A schematic diagram of the bearing-and-shaft assembly is shown in Fig. 1. The test shaft is a replaceable specimen, 2 in. diam and 0.4 in. thick, driven at 426 rpm against a partial bearing having a chord length of 0.25 in. and a width of 0.15 in.

TABLE 2 PREPARATION OF VARIOUS SURFACE FINISHES

Data on final surface: Type of finish	Profilometer, rms microinches: Axial[a]	Circum[a]	Data on finishing operation: Abrasive used	Time, min	Coolant or vehicle	Stock removal, mils	Data on prior surface: Type of surface	Profilometer axial direction, microinches
Rough-sandpapered	8.0	3.5	No. 240 Alundum cloth	0.4	None	0.1	Ground	5
Medium-sandpapered	5.0	2.0	No. 320 Alundum paper	1	10:1 mixture of Sunoco spirits and International Compound No. 155 D.S.	0.1	Ground	20
Fine-sandpapered	1.5	1.0	No. 400 Alundum paper	1	10:1 mixture of Sunoco spirits and International Compound No. 155 D.S.	0.03	Ground	6
Rough-ground	10.0	4.0	3846 K5B Alundum vitrified wheel		Economy Compound in water	5.0	Ground	30
Medium-ground	6.0	2.5	3880 J8BE Alundum vitrified wheel		Economy Compound in water	0.8	Ground	15
Fine-ground	1.5	0.5	37500 H9L Crystolon shellac-bonded wheel		Economy Compound in water	0.2	Ground	9
Medium-loose-abrasive (ring)-lapped	4.5	3.5	No. 600 Alundum with cast-iron ring laps	6	Spindle oil and kerosene	0.2	Ground	11
Medium-loose-abrasive-lapped	3.5	3.5	No. 600 Alundum on flat cast-iron laps	13	Spindle oil and kerosene	0.2	Ground	11
Fine-loose-abrasive-lapped	3.0	3.0	Levigated alumina on flat cast-iron laps	10	Spindle oil and kerosene	0.1	Medium-loose-abrasive-lapped	3.5
Medium-hyprolapped	3.5	3.5	37 XFK6L Crystolon shellac-bonded wheels	6	Lux soap flakes dissolved in water	0.1	Ground	9
Fine-hyprolapped	2.5	2.5	Levigated alumina I7T resinoid-bonded wheels	2	Lux soap flakes dissolved in water	0.05	Medium-hyprolapped	3.5

[a] The "axial" profilometer readings were taken with the tracer point moving parallel to the axis of the shaft. This is the conventional method of taking profilometer measurements because the tracer point moves perpendicularly across the scratches (perpendicular to the "lay") on a cylindrically ground or sandpapered shaft whereas the circumferential directional is nearly parallel to these scratches.

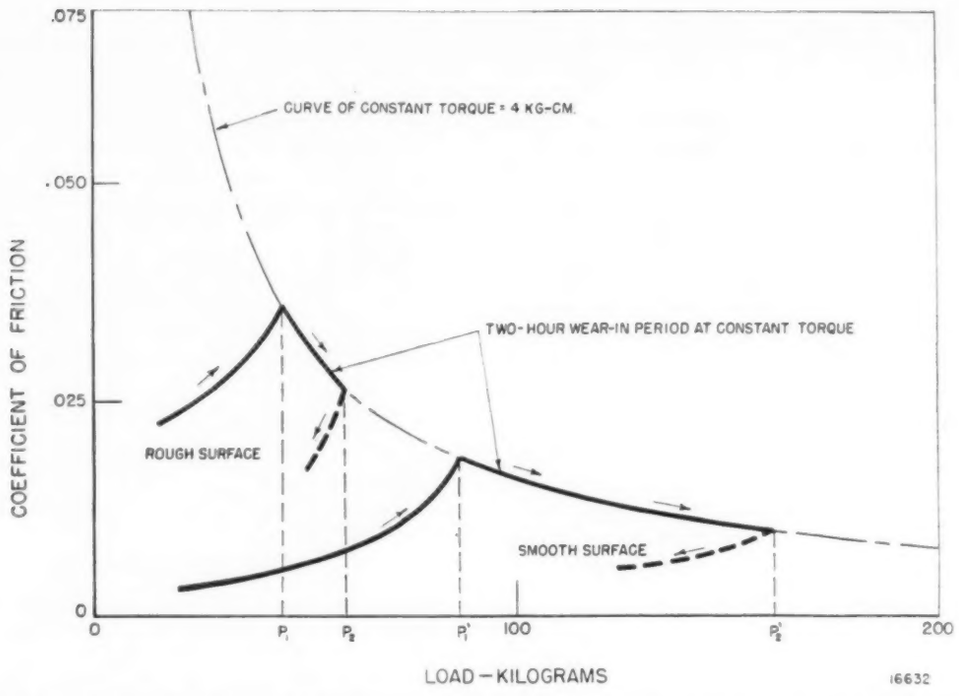


FIG. 2 CHARACTERISTIC FRICTION-LOAD CURVES OBTAINED IN SEIZURE TESTS OF ROUGH AND SMOOTH SHAFTS

(Starting with low loads the coefficient of friction rises smoothly and with increasing slope as the load is increased. The load P_1, when the friction torque reaches the arbitrarily chosen value of 4 kg-cm, is called the "initial seizure load." The machine is then run at this torque for 2 hr, during which the coefficient of friction decreases and the load must be increased to maintain the torque. The load P_2 at the end of this period is called the "final seizure load.")

Ordinarily, the bearing was held rigidly in place, but the effect of pivoting the bearing so that it could accommodate itself laterally to inaccuracies of the shaft was studied. The fact that there was no appreciable difference in the results with the pivoted bearing was evidence that misalignment was ordinarily so small that its effect was negligible.

To insure that each test would be started under identical conditions, the bearing to be used in the test was worn-in against a dummy shaft whose diameter was the same, within 0.0001 in., as the diameter of the test shaft. It was found by experience that care in this prewearing-in of the bearing was of considerable importance in preparing the bearing for the test. If this step was hurried, nonreproducible results were obtained, but when properly carried out the prewearing-in left the bearing with a standard finish and insured a good mating fit with the test shaft. Lubrication and temperature were maintained constant by submerging the shaft in S.A.E. 30 motor oil heated to 250 F. Erratic results in early tests with silver and copper-lead bearings were found to be associated with the formation of a sulphide film on the bearing-metal surface, which increased the friction by variable and uncertain amounts. This filming tendency and the associated incoherent results were eliminated in the standard procedure by desulphurizing the oil with powdered silver and by maintaining a sulphur-free atmosphere of nitrogen over the oil while the test was in progress.

The test procedure adopted after some exploratory work was as follows: First, load is applied in increments according to a set schedule until the frictional torque reaches 4 kg-cm. The load necessary to produce this torque is called the "initial seizure load," although no actual seizure has occurred in our equipment and the designation is thus an entirely arbitrary one. It is a measure of the seizure-resisting quality of the original shaft finish before wearing-in has caused any appreciable change. For a two-hour period following the initial loading the torque is maintained at 4 kg-cm by adjustments of the load. Since the load-carrying ability of the shaft improves during this time, it is necessary to increase the load to maintain the torque at 4 kg-cm. The load on the bearing at the end of this two-hour period is called the "final seizure load," although again no actual seizure has occurred. It is a measure of the seizure-resisting quality of the shaft surface after a moderate amount of wearing-in.

The shapes of typical coefficient-of-friction versus load curves are shown in Fig. 2, one curve representing a rough surface, the other a smooth surface. The choice of a torque of 4 kg-cm for defining the seizure loads is purely arbitrary. This value was chosen because it is high enough to be in the region of incipient seizure, but not so high as to cause damage to the shaft or bearing.

In the field of thin-film lubrication, the coefficient of friction increases as the load is increased. However, as can be seen from Fig. 2, there is often no overlapping of the coefficient-of-friction values for different roughnesses of journal surface. Therefore, if we were to attempt to define seizure conditions in terms of an arbitrary coefficient of friction, we could not compare surfaces in different ranges of surface roughness. But, by writing our definition of seizure conditions in terms of torque or drag force instead of coefficient of friction, we are able to make all the desired comparisons. This means that the range of drag forces obtainable by increasing the load on the bearing is adequate for making comparisons, although when the values for different drag forces are divided by the corresponding loads, in order to calculate the coefficients of friction, the ranges of the coefficients themselves no longer overlap.

In order to give an idea of the magnitude of the quantities involved, it can be calculated that a 100-kg seizure load corresponds approximately to 6000-psi bearing pressure. A torque of 4 kg-cm at a load of 100 kg represents a coefficient of friction of 0.016. These values merely serve to give an idea of the range

covered in the experimental work, and no attempt should be made to apply them numerically to practical bearings.

PRELIMINARY TESTS WITH FOUR BEARING MATERIALS

In the early part of this investigation, studies with four different bearing materials were made for the purpose of selecting one material for use in the more extensive study. Tests of a few different ground and sandpapered surfaces on steel shafts were made against each of the four bearing alloys. The results are given in Table 3.

These results show that the type of finish on the shaft is a factor that markedly affects the load-carrying ability of bearings, although babbitt bearings do appear to be relatively insensitive to the effect of finish, as Underwood (8) has pointed out. For test purposes, babbitt bearings have the additional disadvantage that they squeeze out under heavy loads.

Silver is highly sensitive to finish but is so seizure-resistant that, on good surfaces such as the two better finishes, reported in Table 3, the final seizure loads are higher than the load limit of the machine.

Hard bronze appears to be quite sensitive to the effects of finish, but unlike silver, it is not a particularly seizure-resistant material, and the seizure loads are quite low even with very smooth surfaces.

Bearings of the copper-lead composition were chosen as being most suitable for a more extensive study, since this material is sensitive to the surface finish on the shaft and has a high seizure resistance which is usually within the load limit of the machine. Moreover, it is a material that finds considerable use in aircraft master-rod and main bearings, as well as in other high-speed, heavily loaded bearings where seizure is a factor.

TABLE 3 PRELIMINARY TESTS OF STEEL SHAFTS AGAINST FOUR BEARING MATERIALS

	Data on journal finish				
		Profilometer, rms microinches			
Bearing material	Type of finish	Axial	Circum	Seizure load, kg Initial	Final
Pure silver	Fine-sandpapered	1.5	1.0	103	220[a]
	Rough-ground	10.0	4.0	17[a]	...
	Fine-ground	1.5	0.5	190[a]	227[a]
Copper-lead (28% Pb, 1% Ag, balance Cu)	Medium-sandpapered	5.0	2.0	120	155
	Fine-sandpapered	1.5	1.0	90	161
	Rough-ground	10.0	4.0	44	40
	Fine-ground	1.5	0.5	140	208[a]
Babbitt (7.6% Sb, 3.75% Cu, 0.25% Pb, 88.4% Sn)	Medium-sandpapered	5.0	2.0	80	95
	Fine-sandpapered	1.5	1.0	75	90
	Fine-ground	1.5	0.5	74	..[b]
Bronze (80% Cu, 10% Sn, 10% Pb)	Fine-sandpapered	1.5	1.0	37	56
	Fine-ground	1.5	0.5	46	81

[a] The torque was not raised to 4 kg-cm, and this value of seizure load was obtained by extrapolation of the friction-load curve.
[b] At loads above 100 kg, the babbitt flattened and greatly increased the bearing area, changing the conditions of test so that the final seizure load is unknown.

Although the data given in Table 3 are the results of single tests and were obtained before the method of testing was standardized, they do indicate that the several bearing metals would rate the various finishes in about the same order of seizure resistance. These results also emphasize the rather obvious fact that the seizure loads depend on the bearing material as well as on the journal finish, and consequently the various finishes must be rated by intercomparing the seizure loads obtained on one bearing material.

RESULTS OF TESTS OF VARIOUS FINISHES ON COPPER-LEAD BEARINGS

A more extensive study of the effect of surface finish was made using copper-lead bearings. In most instances, more than one test was made on each type of surface. The results of all tests, together with the average result where more than one test was made, are given in Table 4.

TABLE 4 TESTS OF STEEL SPECIMENS WITH VARIOUS FINISHES AGAINST COPPER-LEAD BEARINGS

	Profilometer, rms microinches			Seizure load, kg		
Type of journal finish	Axial	Circum	Test number	Initial	Final	Bearing wear, mg
Rough-sandpapered	8.0	3.5	112	30	50	24
Medium-sandpapered	5.0	2.0	48	120	155	0
			102	102	230[a]	2
			103	140	208[a]	1
			Avg	121	198	1
Fine-sandpapered	1.5	1.0	44	90	161	0
			104	200	244[a]	0
			105	216[a]	274[a]	0
			Avg	169	226	0
Rough-ground	10.0	4.0	34	44	40	12
			62	36	44	1
			63	30	52	2
			Avg	37	45	5
Medium-ground	6.0	2.5	57	40	84	1
			46	25	65	11
			109	57	...	4
			Avg	41	74	5
Fine-ground	1.5	0.5	107	140	208[a]	2
			108	148	...	3
			Avg	144	208	2
Medium-loose-abrasive (ring)-lapped	4.5	3.5	119	40[b]	...	17[c]
			120	35[b]	...	13[c]
			Avg	38	...	15
Medium-loose-abrasive-lapped	3.5	3.5	76	35	49	11
Fine-loose-abrasive-lapped	3.0	3.0	77	60	95	2
			92	80	109	1
			93	70	91	1
			Avg	70	98	1
Medium-hyprolapped	3.5	3.5	79	30	66	7
			86	50	54	1
			87	60	80	0
			Avg	47	67	3
Fine-hyprolapped	2.5	2.5	80	140	146	0
			88	140	140	0
			89	135	142	1
			Avg	138	143	0

[a] Since the load limit of the Amsler machine is 200 kg, it was not possible to increase the load to maintain the standard torque of 4 kg-cm, and all seizure values above 200 kg were obtained by extrapolation of the friction-load curve.
[b] Galled at this load. Test stopped immediately.
[c] Wear during the brief period up to and including galling.

With some types of surfaces, there is excellent agreement between the check tests. With the fine-hyprolapped surface, for example, the average deviation of the individual results from the mean is only about 2 per cent, but with other types of surfaces the differences between individual results are much larger. Considering all of the tests, however, the average deviation of individual results from the mean is about 12 per cent. This order of accuracy is satisfactory because of the large differences between the various types of surfaces.

The average results are summarized in Table 5, in which the various finishes are arranged in the order of decreasing initial seizure loads. Since these numbers are measures of the resistance to seizure, the various finishes in Table 5 are arranged in order of excellence with the best surfaces at the top. Four of the finishes have outstandingly good seizure resistance. These are the fine-sandpapered, the fine-ground, the fine-hyprolapped and the medium-sandpapered surfaces. The results show little,

TABLE 5 AVERAGE RESULTS FOR STEEL SPECIMENS ARRANGED ACCORDING TO EXCELLENCE AS MEASURED BY INITIAL SEIZURE LOAD

Type of finish	Profilometer, rms micro-inches, Axial	Profilometer, rms micro-inches, Circum	Product of profilometer readings	Average seizure load, kg, Initial	Average seizure load, kg, Final	Average wear, mg
Fine-sandpapered	1.5	1.0	1.5	169	226	0
Fine-ground	1.5	0.5	0.75	144	208	2
Fine-hyprolapped	2.5	2.5	6	138	143	0
Medium-sandpapered	5.0	2.0	10	121	198	1
Fine-loose-abrasive-lapped	3.0	3.0	9	70	98	1
Medium-hyprolapped	3.5	3.5	12	47	67	3
Medium-ground	6.0	2.5	15	41	74	5
Medium-loose-abrasive (ring)-lapped	4.5	3.5	15	38	...	15[a]
Rough-ground	10.0	4.0	40	37	45	5
Medium-loose-abrasive-lapped	3.5	3.5	12	35	49	11
Rough-sandpapered	8.0	3.5	28	30	50	24

[a] Average wear during short tests up to and including galling.

if any, significant difference between the last four finishes listed in Table 5.

As a class, the loose-abrasive-lapped surfaces appear to be somewhat inferior. The ring-lapped surfaces galled at low loads and even the surfaces finished by fine-loose-abrasive lapping with levigated alumina showed poor seizure resistance when compared with the finer surfaces finished by other methods.

EFFECT OF SURFACE ROUGHNESS

It was reasonable to expect that the smoothest shafts would have the best seizure resistance. The results are in general accord with this expectation, but they show rather clearly that some care should be taken in deciding what the effective roughness of the surface really is.

Taper sections[5] of the eleven different finishes are shown at the right in Fig. 3. The sections are arranged in the order of initial seizure resistance of the corresponding finishes, with the best surfaces at the top. It is immediately apparent that the taper sections would have about the same order if they had been arranged in the order of apparent smoothness. In other words, the appearance of taper sections is a fairly reliable indication of the relative seizure resistances of different surfaces.

At the left in Fig. 3, the seizure-test results are plotted against the axial profilometer readings. Neither the initial seizure loads, represented by the solid points, nor the final seizure loads, represented by the hollow points, show good correlation with the conventional axial profilometer readings when all of the data are considered. If, however, each type of finish is considered separately, it is seen that the rougher the surface the lower the seizure load. We may conclude, therefore, that conventional profilometer readings will predict the relative seizure resistance of surfaces which are all finished by one type of operation, but such readings are not very reliable for comparing different types of surfaces.

Somewhat better correlation is found between the seizure loads and the product of the profilometer readings taken in the axial and circumferential directions. Fig. 4 gives an indication of how good this correlation is. There are obvious discrepancies, but taken as a whole the points fall reasonably close to the best curve drawn through them. The average deviation of the initial-seizure-load points from the best curve is about 10 per cent, an error which is less than the reproducibility of either the seizure-load measurements or the individual profilometer readings. The average deviation when the seizure results are plotted against axial roughness alone is about twice the foregoing value, viz., 19 per cent. It is apparent, therefore, that the product of profilometer readings in the two mutually perpendicular directions is a considerably better indication of relative seizure resistance than is the conventional single reading.

These considerations suggest that if roughness is measured by the appearance of taper sections or by the product of profilometer readings, journals prepared by different finishing methods but having the same roughness, as just defined, will have about the same seizure resistance. However, there are two possible exceptions in that fine and medium sandpapering seem to give somewhat better than average results, and loose-abrasive lapping somewhat poorer than average results.

The surfaces lapped with loose abrasive on flat laps have a pattern of rather short random scratches, but those lapped with a ring lap and loose abrasive have a pitted or spalled type of surface (see Fig. 3). The galling which occurred with the ring-lapped specimens is probably associated with this type of surface and such finishes should not be used on journals which must carry heavy loads. Ring lapping is, however, one of the best methods of finishing shafts to high standards of trueness and geometrical accuracy, and in applications where these factors are important, ring lapping should probably be used. A single test was made on a ring-lapped specimen which had been given a light sandpapering sufficient to replace the pitted surface with a pattern of parallel scratches but not sufficient to alter the shaft accuracy. This specimen withstood the highest seizure load of any surface yet tested. A similar sequence of finishing operations would seem promising for shafts which must be dimensionally accurate and carry heavy loads.

This investigation has furnished no direct information on the effect of scratch direction. The results show that the roughness parallel to the scratches must be taken into consideration, as well as the roughness measured across the scratches, but no surfaces were made up for test with parallel scratches in an axial direction that could be directly compared with the cylindrical scratches on ordinary ground specimens. For this case it is not sure whether or not there would be a difference in the seizure resistance.

The following example illustrates the type of conclusion which can be drawn from the present investigation: Given two journals, one with a perfectly random scratch pattern and the other with circumferential scratches. Suppose we find that the ordinary axial profilometer readings are the same on the two journals. Then, we can be quite sure that the one with the circumferential scratches will have better seizure resistance because its two-dimensional roughness, as determined by the product of axial and circumferential readings, is certain to be lower.

THE WEARING-IN OF SURFACE FINISHES

The difference between the final and initial seizure loads is a measure of the ability of the finish to wear-in rapidly to a better

[5] Taper sectioning (9) is a very revealing but destructive method of studying surfaces. The surface to be studied is electroplated with a layer of nickel and then is ground at a small angle with the original surface. The ground section is finally metallographically polished and then lightly heat-tinted to increase the contrast between the steel, which is darkened, and the nickel which remains bright. The result is a section which cuts through the steel-nickel interface, at a small angle of inclination. The depth of scratches and depressions is magnified in the section by an amount which depends upon the angle of taper, in this work 2 deg 17 min giving a vertical magnification of 25×. Photomicrographs at 100× optical magnification show the surface with a vertical magnification of 2500× while the horizontal magnification is only 100×. Scratches which appear to undercut the surface as in the third, sixth, and tenth sections in Fig. 3 are simply random scratches which are inclined to the direction of taper and, consequently, do not cut perpendicularly across the section interface.

TAPER SECTIONS OF SURFACES
SOLID POINTS ARE INITIAL SEIZURE LOADS

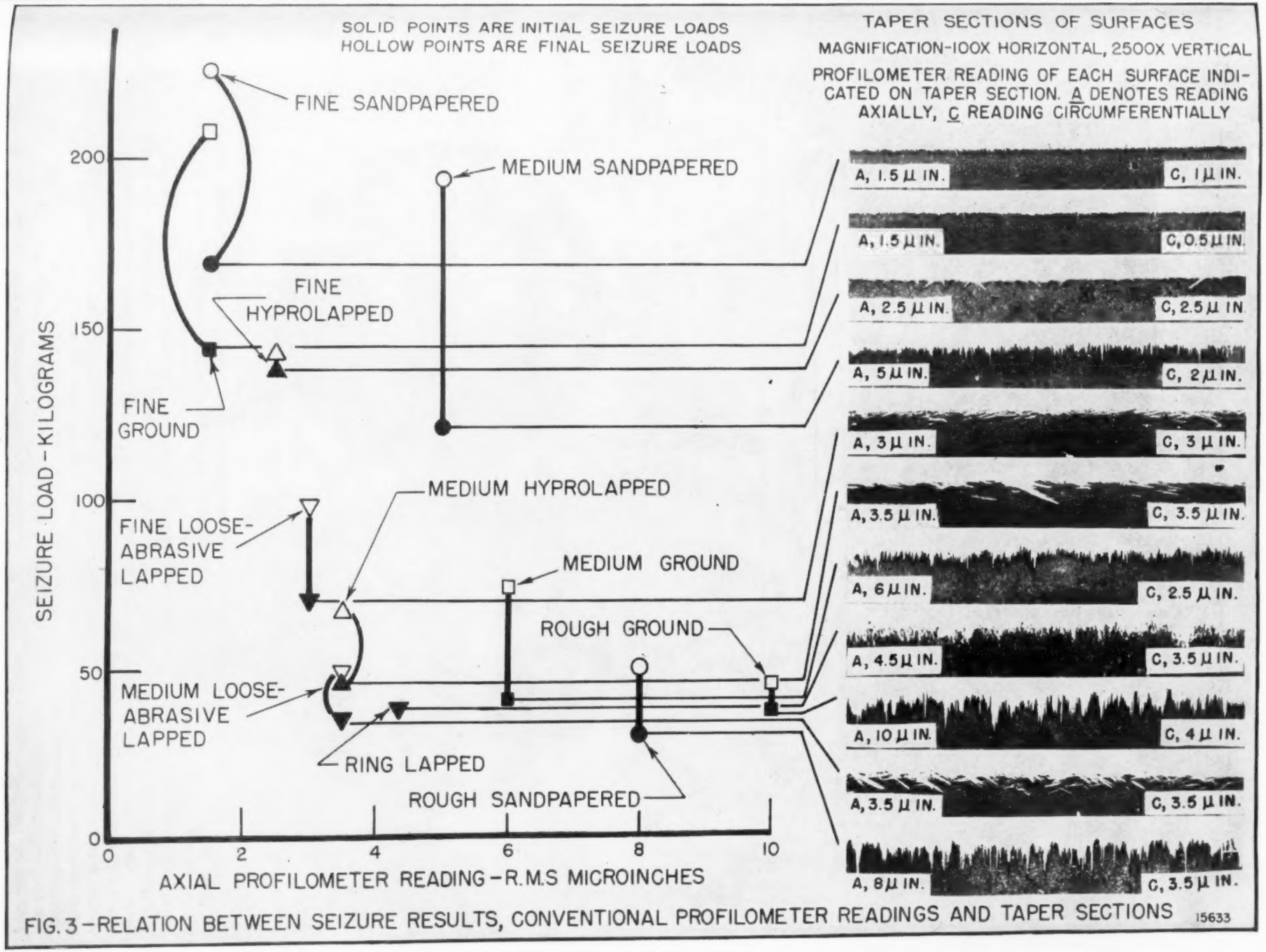


FIG. 3 – RELATION BETWEEN SEIZURE RESULTS, CONVENTIONAL PROFILOMETER READINGS AND TAPER SECTIONS 15633

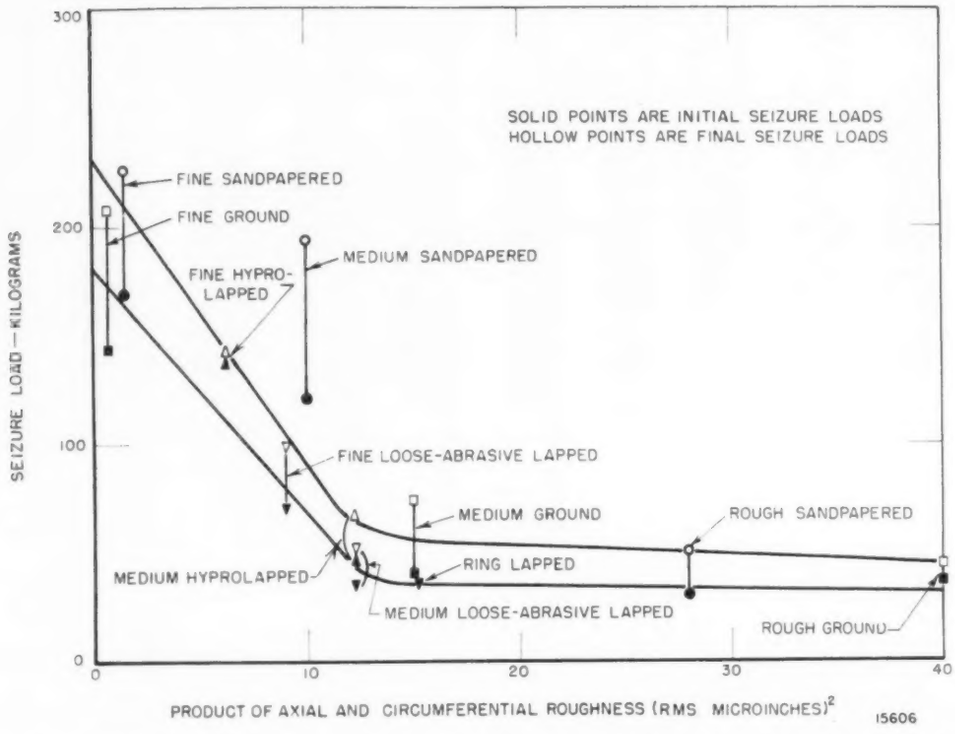
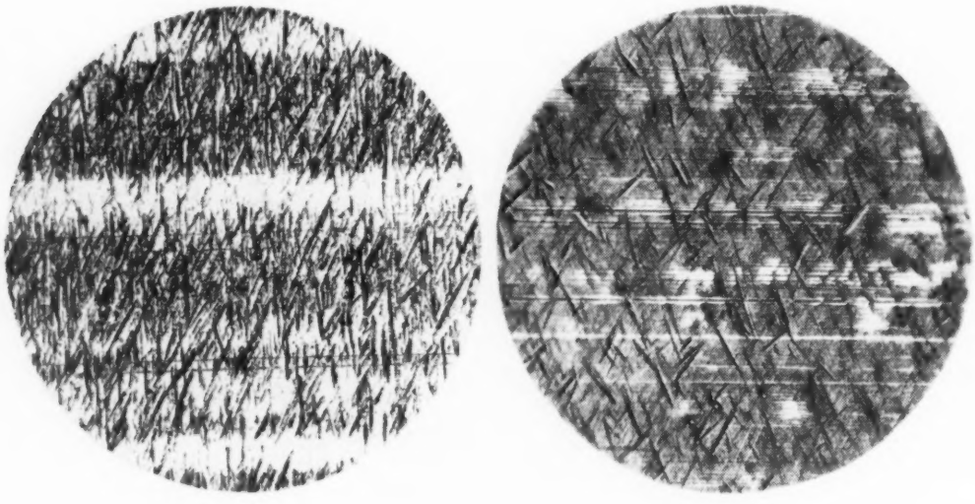


FIG. 4 INITIAL AND FINAL SEIZURE LOADS, PLOTTED AGAINST PRODUCT OF PROFILOMETER READINGS THAT WERE TAKEN IN AXIAL AND CIRCUMFERENTIAL DIRECTIONS ON TEST SHAFTS

(The average deviation of the initial-seizure-load points from the best curve through them is 10 per cent, as against 19 per cent when the seizure loads are plotted against the axial profilometer readings alone.)



(*a*) (*b*)

FIG. 5 PLAN-VIEW PHOTOMICROGRAPHS OF SHAFT SURFACES AFTER WEARING-IN; MAGNIFICATION 100×

(*a*, 3.5 μ in. loose-abrasive-lapped surface; *b*, 2.5 μ in. hyprolapped surface.)

surface. This is shown graphically in Fig. 3 by the vertical distance between the pair of points representing a particular finish. The fine-ground and the fine- and medium-sandpapered surfaces all wore-in rapidly to surfaces having much higher resistance to seizure. The fine-hyprolapped surface, on the other hand, wore-in very slightly, and the other surfaces wore-in by intermediate amounts.

Plan-view photomicrographs at 100× magnification in Fig. 5 show the appearance of a medium loose-abrasive-lapped surface and a fine-hyprolapped surface after wearing-in. The smoothing that took place due to wearing-in is shown by the light areas. It is obvious that very little change took place in the fine-hyprolapped surface and this agrees with the test data. In both cases, the smoothing covered only a small proportion of what would ordinarily be considered as the contact area between shaft and bearing metal.

The top four taper sections in Fig. 3 show the fine-sandpapered, fine-ground, and fine-hyprolapped surfaces and the medium-sandpapered surface. A study of these indicates that the surfaces which wear-in most readily have a fine-scale rough-

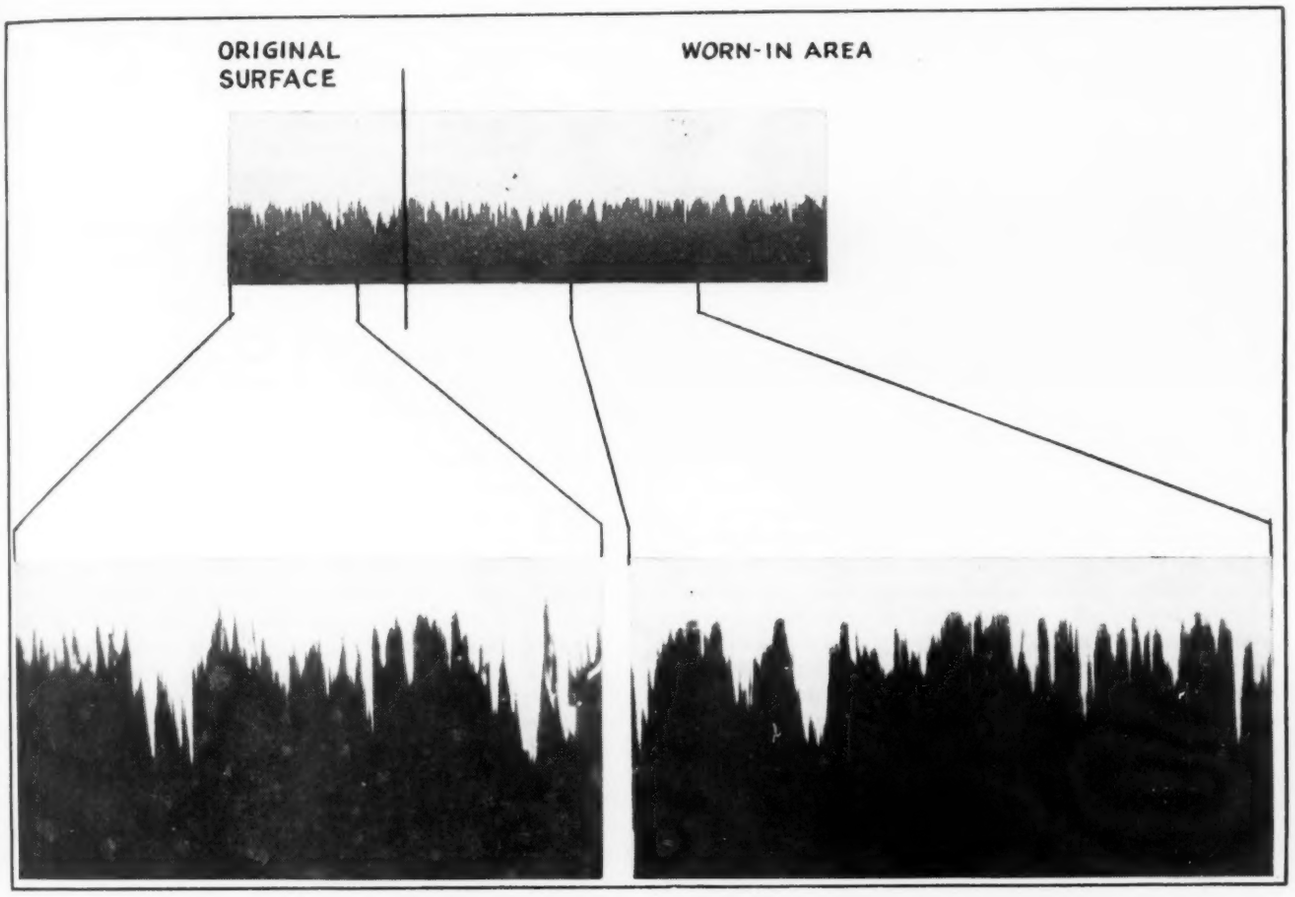


FIG. 6 TAPER SECTIONS, SHOWING ORIGINAL SURFACE CONTOUR OF GROUND SHAFT AND CONTOUR OF WORN-IN AREA ON SAME SHAFT
(Upper photomicrograph, horizontal magnification 100×, vertical magnification 2500×; lower photomicrographs, horizontal 500×, vertical 12,500×. The upper photomicrograph shows little difference between the area worn by the bearing and the original surface. At higher magnification, however, it is apparent that the high points are actually rounded off during wearing-in.)

ness sometimes referred to as "fuzz." The taper section of the fine-hyprolapped surface, which wore-in hardly at all, shows that it is practically devoid of fuzz, its surface being quite smooth except for isolated scratches left from the prior finishing operation. If we have a choice between the fine-ground and the fine-hyprolapped surfaces, whose initial seizure resistances are identical, then for an application where maintenance of the operating characteristics of the original surface is of prime importance the fine-hyprolapped finish would be best.

However, for an application where rapid wearing-in to a highly seizure-resistant surface is desirable, then we would undoubtedly pick the fine-ground finish. This does not mean that the fuzz of itself is beneficial, since it is obvious that with less fuzz the ground surface would have a still higher initial seizure resistance. The results do show, however, that fuzz is not harmful on a journal which has a reasonably high initial seizure resistance.

The details of the wearing-in process are not entirely clear, but we have made some experiments that are quite illuminating. There is undoubtedly a tendency for the surface of the shaft to be smoothed during the wearing-in, but ordinary measurements do not disclose what has happened, although the visual appearance of the surface is likely to be somewhat smoother.

Profilometer readings before and after wearing-in are identical, and no differences in contour can be detected with the Brush surface analyzer. When examined at ordinary magnification, taper sections of a worn-in surface look very much like sections of the original surface. If, however, the taper sections are examined at magnifications of 500× or more, then smoothing resulting from wearing-in becomes apparent.

A ground shaft was worn-in against a silver bearing for six hours at the standard 4 kg-cm torque. During this six-hour period the seizure load increased from 67 to 190 kg. The silver bearing metal contacted the shaft over a circumferential band 0.15 in. wide on the face of the specimen. It was possible, therefore, to make a single taper section which extended across the face of the specimen and included original as well as worn-in areas. By careful measurements on the specimen before and after sectioning it was possible to locate the edge of the bearing track in the final taper section.

Fig. 6 shows three typical photomicrographs from a large number that were taken across the section. No appreciable smoothing or other wearing-in effects can be seen at 100×, but the micrographs taken at 500×, giving an effective vertical magnification of 12,500×, show clearly that the highest points are slightly rounded off. The smoothing is too small to be detectable with ordinary tracer-point methods. It is, in fact, very slight, but it undoubtedly represents a large increase in the effective load-supporting area and a corresponding decrease in local pressures which caused the seizure load to increase from 67 to 190 kg at constant torque.

In order that there should be no misinterpretation of the relationship between taper-section appearance and the actual surface contour, an ordinary section normal to the surface of this

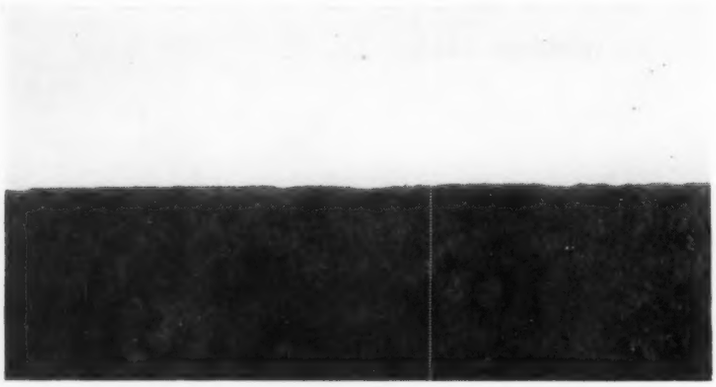


FIG. 7 NORMAL (90-deg) SECTION OF THE SAME 8 μ IN. GROUND SHAFT SHOWN AS TAPER SECTIONS IN FIG. 6; MAGNIFICATION 500×

same specimen is shown in Fig. 7 at 500× magnification. This is the same horizontal magnification as the taper sections at the bottom of Fig. 6. The normal section shows the correct slightly undulating nature of this ground surface. It is difficult to believe but actually true that the taper section, so valuable for study and yet so exaggerated in appearance, is a proper representation. Even plan-view photomicrographs of ground surfaces are misleading in appearance because the sharp reflection of light from the really gentle undulations makes them seem quite different from their true cross section.

All this emphasizes the extremely minute nature of the smoothing that took place during wearing-in and accounted for a rise in seizure load from 67 to 190 kg, an increase of 284 per cent. The actual area of contact is thus indicated to be only a small percentage of the conventionally calculated area, even for the finely finished and accurate surfaces being dealt with in this investigation.

If the effective area of contact is such an important factor in seizure, it becomes apparent that large-scale roughnesses, such as waviness, flat spots, and grinding chatter, are also probably very important. The exceedingly good results for seizure resistance, observed with the ring-lapped specimen that had been given a light, very fine sandpapering, as previously described, support this view. Its surface should have been very true and free from waviness and chatter, and the very fine sandpapering reduced the effective surface roughness to a low value, so that the specimen approached perfection and was highly seizure-resistant.

One might well ask if the improvement in load-carrying ability, which has been attributed to the wearing-in of the shaft, is not an improvement of the shaft-bearing combination. Strictly speaking, this is true, but there are reasons to believe that the contribution of the softer bearing metal during wearing-in is practically negligible. The bearing does, of course, experience wear of measurable amounts which are roughly dependent on the roughness of the shaft (See Tables 4 and 5), whereas the wear of the shaft is too small to measure. Wearing the bearing, however, does not improve its surface because its microcontour is determined solely by the microroughnesses of the shaft. Only as the shaft becomes smoother does the surface of the bearing improve.

SUMMARY

Tests to study surface finish of journals as affecting friction, wearing-in, and seizure of bearings were made on an Amsler machine under the conditions given in this paper. Fine finishes were studied, the roughest having a profilometer reading of only 10 microinches.

It was found that there was rather good correlation between the seizure results and the product of profilometer readings taken in the axial and circumferential directions. Those surfaces having higher roughness-product readings had greater seizure tendency. This was approximately true irrespective of the finishing methods employed, which included grinding, sandpapering, loose-abrasive lapping and lapping with bonded abrasive wheels, but sand-papered surfaces gave rather better than average seizure resistance and loose-abrasive-lapped surfaces rather poorer than average seizure resistance. However, a loose-abrasive-lapped surface finished by ring lapping, and therefore exceptionally free from chatters and other defects, gave exceptionally good results when extremely fine abrasive paper was used lightly to finish its surface before testing.

The seizure results of all specimens also correlated well with the appearance of taper sections of the surfaces.

A study by means of taper sections and photomicrographs of the mechanism of wearing-in showed that the surfaces which wore-in most readily had a very fine-scale roughness sometimes referred to as "fuzz." This fuzz is not indicated to be harmful on a journal which has a sufficiently fine surface finish as to have a reasonably high initial seizure resistance.

One effect that takes place during wearing-in was shown to be an extremely minute smoothing of the topmost part of the surface roughnesses, and this produced a large change in the frictional characteristics. The actual area of contact is thus indicated to be only a small percentage of the conventionally calculated area even for the finely finished and accurate surfaces being dealt with in this investigation. Trueness and large-scale roughnesses such as waviness, flat spots, and grinding chatter are also probably very important.

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THE WORLD WE WANT[1]

By LIEUTENANT RAMON WYER

TODAY, our country faces the greatest crisis in its history. Naturally, our first attention must be devoted to winning the war on the battlefield, to providing the men and guns and tanks and planes necessary to crush the enemy. Nevertheless, we cannot count the war as won, merely by being victorious on the battlefield. Although we win the war, we may still lose it. As happened in the last war, we may be victorious in battle but impotent in postwar readjustment and reconstruction. We may sacrifice hundreds of thousands of American lives to banish the threat of Nazi domination and then forfeit a golden opportunity to make their sacrifice really worth while by building a better world in which to live after the war.

Unless we use the heat of this greatest catastrophe of all times to forge a lasting and substantial improvement in our society, we will have failed in our trust to our fighting men. We must be prepared, when victory is won, to take the lead in building that better world—"The World We Want."

IT MUST BE CREATED

The first step toward "The World We Want" is recognition that its evolution will be slow unless we give it studied planning and direction. It will never be just found but will have to be planned for and created, if we are to enjoy it at all during our lifetime. After millions of years of slow evolution along the trail of his animal ancestors, man has finally emerged in the last few hours on the clock of eternity as the only member of God's Kingdom to be able to shape his own destiny. And in only the past few seconds of eternal time has man risen above the limitations of physiological energy.

In less than a century the engineer has created a new world of plenty by harnessing the energy of our natural resources. In this new world the dreams of the ages of plenty, security, leisure, and freedom from toil have been brought within the reach of millions of people. But even in this brief period of a few decades, progress toward "The World We Want" has been painfully slower than necessary, because most of our progress has been aimless and has evolved from "trial and error."

The leadership of the engineering profession in creating a new "world of plenty" through the application of physical science is unquestioned. But the profession's contribution toward developing a broad and fair enjoyment of our world of plenty has been less noteworthy. The engineer has left the fields of economics and political science, as well as social science, to others. Nevertheless, the engineer's methods of fact finding and clear thinking are just as necessary and applicable to those other fields. Furthermore, the engineering profession, with the courage and will to plan and lead, could influence postwar reconstruction to a great extent and make a further everlasting contribution to the progress of mankind to match the "world of plenty" which it already has created.

The purpose of this article is to outline, in general terms, the nature of "The World We Want." Without attempting the pretentiousness or detail of a blueprint, it will develop some of the objectives of postwar reconstruction to serve as guide for further thought and discussion. These objectives must be general at this early stage, for the means of carrying them out are still too remote to be planned in detail. The program is offered for America and for Americans, but the basic principles it presents could be applied all over the globe to whatever extent this country may participate internationally after the war.

[1] Based on extended study of "Proposed Specifications for the World We Want to Build," by Samuel S. Wyer, consulting engineer, Columbus, Ohio.

THE INDIVIDUAL

In "The World We Want" the sole justification for our social order must be human welfare, with the continuing welfare of the people our dominant objective. To protect the value and dignity of the individual, we must nurture the sacredness of human personality by safeguarding prudence, initiative, social ideals, intellectual freedom, and spiritual freedom. At the same time we must distinguish between the political slogan, "All men are created equal," and the obvious biological fact that men are created decidedly unequal. In their physical, mental, or spiritual capacities, men are made with widely varying capacities and traits; and all of these variables are still further modified by environment.

Progress always has come from outstanding leadership of individuals or small minorities and never from the masses. Such individual leaders or small groups have had the courage to brave criticism by stepping out in front. There always should be opportunities for individuals of unusual ability to rise above their fellow men. Coupled with this opportunity for advancement, there must be curbs to prevent such outstanding individuals from using their talents for antisocial purposes. In other words, the opportunity for unusual leadership must always be related to its direction toward and application in the broad public interest.

In our plans we must recognize that most of our troubles come from wrong-acting human beings. If, by political magic, we could change our social order overnight into any of the current forms of "Utopia," we would find that we still had the same wrong-acting human beings to deal with the next morning. Over 2300 years ago, Plato, the intellectual patriarch of old Athens, developed a blueprint for a "perfect" society, in his "Republic." His plan has been copied many times since, but always without success, because it required perfect citizens in order to function. Since our fellow men will always be human, rather than perfect, we should not waste time trying to change human nature. Instead, our sole emphasis should be to alter human behavior, rather than human nature, by setting up necessary and reasonable curbs to control it.

These curbs need not destroy individualism. What we need is to make our individualism less "rugged" and more socially responsible. In other words, we should apply the Golden Rule. The opportunities for initiative, advancement, self-expression, and leadership should impose upon each individual corresponding duties to use them in the public interest.

GOVERNMENT

Government must be kept the servant of the people, so that it exists for the people rather than the people for it. That is the sharp contrast between democracy and totalitarianism. In democracy the government protects the individual. In totalitarianism the individual belongs to the government. In democracy the individual has many rights which government must respect, while in totalitarianism there are none. In democracy we can disagree agreeably. Under totalitarianism we would have to agree disagreeably. Government must be kept an instrument of public service rather than of domination.

As aptly stated by former Chief Justice Hughes, "We are here not as masters, but as servants, not to glory in power, but to attest our loyalty to the commands and instructions laid down by our sovereign, the people of the United States, in whose name and by whose will we exercise our brief authority."

The true function of government is to do for individuals and groups what they cannot do for themselves. We need to repudiate the widespread belief that it exists for the benefit and economic relief of certain groups. Certainly, one of the most difficult problems following the war will be limitation of governmental enterprise to its true function. Prewar doles to business, to labor, to voting loafers, or to youth will not be forgotten, no matter how long or how hard the conflict may be. Militant taxpayers' leagues will be needed to fight the pressure of selfish interests and to force governmental agencies to live within their incomes.

The public must be educated to recognize that government ownership is merely political management of property. It can be no worse or no better than the politicians who do the managing. The only difference between public ownership and private ownership is the management, since the people's savings furnish the capital for both. The managerial difference is between political appointees and men trained in industry.

After the war we will be face to face with the issue of state capitalism versus private enterprise. Regardless of the fancy and misleading labels used when a governmental agency takes the taxpayers' money or credit and goes into business in competition with private industry, it is state capitalism. To talk about using state capitalism as a yardstick for performance by private industry is nonsense. The tax exemptions, railroad-freight rebates, trick accounting, and other hidden subsidies that favor state capitalism make it impossible to secure results comparable with private enterprise. If, by our democratic techniques, the voters or their chosen representatives decide that the government should enter into competition with private enterprise, then the entire industry involved, and not just a part, should be taken over. These two forms of capitalism cannot exist side by side in any industry. One or the other must go.

NATIONAL PLANNING

While the discontinuance of governmental relief and partiality to special groups would be a great step forward, the greatest improvement in our national government that could be effected during our lifetime would be the establishment of adequate national planning—the intelligent co-ordination of the country's production, financial, and distribution activities. The increasing interdependence of all economic and social groups makes national planning mandatory if we are to avoid economic chaos.

This country was founded on principles of free competition and got along for nearly a century without any serious economic restrictions. The basic elements of economics were given free play, and the normal action and reaction of supply and demand kept the business life of the country in fairly good balance. Of course, the pace then was slow and business organization was simple, compared to present-day standards, but the system worked fairly well.

With the dawn of modern industrial organization fifty or sixty years ago, the tempo quickened and the structure became more complicated. Those changes, along with awakening social ideas, proved to the nation that unrestricted competition in business was frequently destructive and resulted in the survival, not of the best, but of the most ruthless. The result was a series of restrictive laws to protect fairness in business and to stamp out ruthlessness, one of the better-known of which was the Sherman Anti-Trust Act in 1890. These laws served their purpose well, particularly in earlier years, and tamed "big business" from the wild, clawing monster that it was in the 1890's to the docile, hard-pulling, work animal that it is today. However, while they served their purpose well, they imposed artificial restrictions upon commerce which prevented natural economic forces from providing the readjustments in our business structure which had been more or less automatic previously. The interference of these restrictions with the regular economic forces of action and reaction became more acute after World War I and finally culminated in the Great Depression.

Many businessmen clamor for a return to the old way of doing things. But most of these restrictive laws have provided social benefits which have proved worth while and are here to stay. Thus it is foolish to argue that business should be freed of them and allowed to go back to the outmoded principles of laissez faire. The trouble with business has been, not the limitations which are imposed upon it, but the fact that these restrictions have prevented the action of balancing economic forces for which no substitute for keeping our economy in balance has ever been provided. In other words, it is the lack of a new "governor" for our national "steam engine," to replace the old-style one which was removed fifty years ago, that has been the seat of our economic ills. The only kind of "governor" that ever will be effective is a thorough system of national planning—a completely co-ordinated program of national business co-operation geared to the modern pace and complete enough to provide broad economic balance without abuse. Anything less would be like trying to regulate the speed of a steam engine by a hand valve.

If our system of free enterprise is to continue, we are going to have national planning in one form or another before long. The only debatable question is, "How?" The main issue is between autocratic governmental planning from the top down, as against democratic industrial planning from the bottom up. There are two possible routes ahead. One is the route of compulsion, destruction of free enterprise and private property, abolition of constitutional rights for the individual, and subordination of the individual to the government. Parts of our New Deal planning efforts have been in that direction and will be expanded unless a more satisfactory alternative can be put into effect. The other route would be the democratic way of planning from the bottom up, through voluntary, self-governing associations composed of representatives of management and labor. Voluntary action can create better planning than any governmental agency and would be much more palatable to Americans.

Details of a proposed system of national planning are not offered here, except to note that it should be organized gradually, possibly over a period of years, and that a constitutional amendment should be passed to give Congress the power to organize planning. The abortive effort of the NRA showed the bad effects of a hastily prepared, compulsory program placed into effect too rapidly. We should learn from that sad experience and develop a well-prepared, voluntary program to be installed slowly.

MANAGEMENT

In recent years, the engineering profession has taken the lead in sponsoring the development of a new type of management. Old-style business leadership, with its narrow principles of selfish ownership and ruthless disregard for public interest, is being displaced with a new leadership, enlightened and socially conscious. Business management is now coming to be regarded more and more as a profession, with requirements for formal training and ethical standards in the making. Just as city government is moving from the old methods of political control to the modern city manager, so business is shifting from

ownership-management to management by professionals, specially trained for their duties. This transition from the old "get-rich-quick" school to the new leadership may be speeded up by the present conflict and the readjustments to follow. The increasing numbers of well-trained businessmen who have been young enough and sufficiently elastic since the debacle of 1929 to have absorbed the beneficial aspects of the social revolution of the last decade may take the upper hand over the old-timers with their outmoded ideas of management.

This new leadership would force out of the seats of the mighty in business the selfish leaders who have used their opportunities for personal aggrandizement. Inflated executive salaries, figure-head directors, and various unethical practices just within the law would be abandoned. The time is approaching when men will have to dedicate themselves to careers of professional service—in the same way that engineers do—before they may enter the privileged ranks of management.

The engineering profession can stimulate, in several ways, this coming development and emergence of business management as a profession. The engineer-manager is better equipped for the role of management than either the lawyer-manager, with his bias-trained mind, or the up-from-the-ranks-manager, with his lack of broad training and background. The engineer's impartiality in facing facts and his training in science and materials give him an advantage over all others in the race for top supervisory positions. It is the responsibility of this profession to capitalize upon that advantage and to develop it fully, not selfishly but in order to speed up the maturing of management as a true profession.

There are several ways in which the engineering profession can take active steps to develop that advantage more fully. The greatest handicap of the engineer-manager is his lack of training in human relations. The man up from the ranks has to prove his mastery of those relations before he is able to rise from the ranks. The engineering graduate, on the other hand, has had little training or experience, if any, in human engineering and frequently starts to work in a capacity where opportunities for learning even the rudiments of how to get along with people are limited. This lack of basic training can be overcome by establishing more and more study of human relations in the engineering schools. Professor Gow at M.I.T. and others have blazed a brilliant trail in teaching human engineering as a definite course. This development should be broadened until courses in humanics are an integral part of the curriculum of every engineering school in the country.

Not only are our engineering graduates deficient in their understanding of human relations, but they are receiving practically no formal training for leadership. Leadership could be taught, the same as physics or applied mechanics. Of course, not every college student is a potential leader, just as only a few are potential physicists, but study of the principles of leadership should be an important part of every engineer's education. Regular courses, based upon the attributes needed for leadership, with laboratory or field practice to demonstrate those attributes and training of the students in techniques of developing them both in themselves and in others, should be established in all engineering curriculums.

This emphasis upon human relations and upon leadership should be motivated by all of the engineering societies with greater force than at present. Although substantial progress has already been made in breaking down the earlier barriers between the technical phases of engineering and the broader aspects of business management, the societies could devote more attention to the problems of labor, supervision, personnel, organization, and individual leadership. Eventually, there should be a strong professional society for business managers, comparable in standards and scope to the engineering societies.

LABOR

Since the labor movement first started in this country, labor and management have been antagonists. Until the last decade management had the upper hand and frequently took unfair advantage of its position. With the growing strength and popularity of the labor movement during the depression, however, the pendulum shifted so that labor has had the upper hand for nearly a decade and likewise has frequently taken unfair advantage of its position. In "The World We Want," this antagonism between labor and management will have no place. Instead, they will have to act as joint partners in the creation and distribution of usable wealth. Neither management nor labor can work alone. Both are mutually interdependent. Labor cannot work without leadership, planning, and direction, and management is useless without many hands to do the work.

The seasoning of the labor movement in this country during years to come will provide it with more responsible and more stable leadership than it has had in the past, which will help to dissolve the classic antagonism with management. Further, the development of the new leadership in management will also contribute toward bringing the protagonists of labor and management together as joint partners. However, the labor movement has gained several advantages, unfair not only to management but also to its own membership, which should be abolished as soon as the war is over. The changes which should be made in national labor legislation are as follows:

1 *No closed shop.* Any worker should have the right to join, or not to join, any union, as he sees fit. Membership in a particular union, as a qualification for employment, is unfair to the worker and places him at the mercy of the union without judicial recourse, thus destroying his constitutional right to work.

2 *Incorporate unions.* Our past experience with unincorporated unions shows that they are lawless and irresponsible with respect both to employers and to their own members. The public interest requires that unions should be made legally responsible for their actions.

3 *No sit-down strikes.* The sit-down strike is an illegal technique of Communistic revolution. It destroys the human right of ownership and must be outlawed.

4 *No sympathetic or jurisdictional strikes.* Such strikes are an unfair application of union strength to innocent bystanders, in order to achieve results which cannot be gained fairly.

5 *No interference with labor-saving machines or methods.* Slowdowns or refusal to accept improvements in machinery or methods are shortsighted and selfish techniques which interfere with improvement in the standard of living for everyone.

6 *Pay for output.* Productivity is the only sound basis for remuneration, and any limitation upon "pay for output," other than minimum wages, should be outlawed.

7 *Promotion for ability.* Restriction of promotion to seniority stifles initiative and breeds incompetence. Scientific methods of rating employee performance are now adequate to avoid the abuses which created seniority lists, and promotion on seniority only should be outlawed.

The effort to place the foregoing principles into effect must be sponsored fairly and must not be used to bring back other practices, just as unfair, which we have outgrown, such as discrimination because of union membership or arbitrary dismissal without cause. Many of the recent gains of the labor movement are worth while and must be protected.

In addition, provision should be made for every worker to get justice in any controversy with either his employer or his union, without paying tribute to any individual or organization. The National Labor Relations Board, with its prejudice and un-

judicial proceedings, was a poor example of justice for either workers or employers. Legislation should be passed to enable each United States District Judge to appoint one or more proctors of industrial relations as officers of the court. The proctors would have the authority to hold public hearings, take testimony, summon witnesses and records, and make findings. All of their findings would be reviewable by the court. Petition for the hearing of a controversy could be made by any worker, union, or employer who believed that he had not received justice. When such a petition was accepted, the controversy would be under the jurisdiction of the court and corollary actions of intimidation or violence could be treated as contempt of court.

FARMERS

In "The World We Want" farmers will neither be discriminated against nor coddled. There have been many instances of discrimination in the past. Such injustices have given opportunist politicians, who are more interested in the farmer's vote than in really solving his problems, an opportunity to exploit his woes. Recognition must be given to the farmer as the original wealth creator. The miner and fisherman merely find wealth that is already created in nature. Other workers merely alter the form of basic wealth or perform services upon it. The farmer, on the other hand, enters into a partnership with Nature for creating something that was not in existence before. He represents the only class of our population that can be capitalist, management, and labor, all at once. Thus, farmers are unique and should not be regarded merely as workers.

Farming is a way of life rather than a business to most farmers. A farm is more than just a work place. It is a nursery for the proper growing of human stock under ideal, natural conditions. Therefore, we must fight the most vicious rural trend of today, which is the shift from individual ownership and operation of farms to tenant operation. Tenant farming is an undesirable relationship when practiced on a large scale. It kills individual initiative and destroys proper rural economic balance. Too much purchasing power goes to the owners, not enough to the workers, with resulting poor living conditions and class hatred.

One of the outstanding handicaps of the farmer today is the price label on his land. The land itself is not real wealth, since real wealth can be measured only by the capital and labor expended in making it usable. The price label on most farmland reflects land speculation by speculators not interested in creating wealth but merely in making an unearned income for themselves. There will have to be substantial deflation in land values before farming can be made profitable.

The program of national planning, which has been described, would have to include adequate income for the farmers, since about 45 per cent of our people are dependent upon farm prosperity. A fair scale for parity of prices, based upon relative living standards of the farm and the industrial groups should be established, in place of the present methods of trying to recreate relative standards of living several decades old.

YOUTH

Substantial changes should be wrought in our attitude toward youth. The New Deal brought forth two new activities for young people, one of which was commendable, the Civilian Conservation Corps, and the other of which was unjustifiable, the National Youth Administration. Provision should be made for expanding the activities of the CCC on a much larger scale after the war. We should make a period of a year, or so, at physical work, either on a farm, in a plant, or at a work camp the compulsory duty of every boy and girl. While such compulsory duty might be distasteful to many parents who might approve it for other parents' children, it could become one of the most constructive influences in building strong, self-reliant citizens for the years to come.

The increasing number of college students, the coddling of young people due to lack of jobs in the early years of the depression, and the better and softer standard of living to which we all hope to return again have contributed to giving great numbers of young people the idea that the world could run smoothly without plenty of hard physical work. The effect of that myth upon our present war effort is incalculable, and its long-run effect upon several generations of young people could wreck this nation. We need to make respect for hard labor one of the duties of every citizen, and there is no better time of life to get that point across than in the late 'teens.

We must combat the idea that youth, because it is young, must be nursed along. National planning should provide that every young person have an opportunity to establish himself or herself as an economic producer, without a period of tragic disillusionment. But, at the same time, we should stimulate initiative, aggressiveness, and hard work in all youngsters. Until the war forced a revision of its policies, the National Youth Administration represented all that could be undesirable in the training of boys and girls. There is no place for a national laboratory of "self expression," inefficiency, or loafing. Instead, we should provide a national program of work opportunity to show young people that the world does not owe them a living—merely the chance to make a living by their own efforts.

EDUCATION

While we are taking other steps to make our young people stronger and more self-reliant, we should improve our methods of education. There must be wider recognition of the variation of learning capacities of pupils. Schools cannot create brains but can only develop what Nature already has furnished. The greatest teaching opportunity lies in the discovery and development of individual abilities. Uniform educational patterns are dangerous and inefficient. A man at a lathe cuts at just the right speed and takes off just the amount of metal necessary to give a satisfactory finish. He treats each kind of metal that he handles for what it is, adapting his technique to the metal. If he tried to use fixed cuts and speeds for all kinds of metal, he would have a mess. Our present methods of uniform education are producing the same kind of mess. The aptitudes and abilities of children vary as widely as the types of metals used in a machine shop. Some learn slowly and some learn fast. Some can be led, others have to be pushed. Some shine at mathematics, some at languages, and some at athletics. The progressive education movement, in so far as it really develops individual abilities and is not merely an excuse for pupils to avoid hard work, should be stimulated and promoted as much as possible.

CONCLUSION

Although our backs are to the wall on the far-flung battlefields of the globe and the great struggle of World War II still lies ahead of us, we must start planning now for postwar adjustments if we are to be prepared to make them. Unless we are ready to create "The World We Want" when the war is over, the blood of myriad Americans may have been shed for naught. Will we cleanse the world of the smudge of Nazi thralldom, only to stop there with our job incomplete? Or will we carry on through to a better world which will make the sacrifice of hundreds of thousands of American lives seem less in vain? Will our war-weary sons and brothers return victorious from foreign shores to find us unprepared for their hard-fought victory? No—not if we have planned for "The World *They* Want." We must not let them down.

Twenty Years of PROGRESS *in* DOMESTIC OIL HEATING

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BRIEF HISTORY OF DOMESTIC OIL BURNERS

EXCELLENT books on oil burners have been written, some as old as the 1904 Reports of the U. S. Naval Liquid Fuel Board, others as recent as 1941. The introductory section of this paper, therefore, is intended only to offer a kaleidoscopic picture of domestic oil burners and oil-burning units since their appearance on the market. For greater detail, the reader is referred to the Bibliography at the end of the paper.

EARLY VAPORIZING-TYPE BURNERS

Fig. 1 is a sketch of the "Astrakan" stove found in Russia as early as 1860, which may be referred to as the ancestor of oil-burning stoves. That contraption is contemporaneous with the first attempts at burning heavy fuel oil. The Russians appeared to have been very successful because, from the start, they had recognized the advantage of using steam as a soot preventer. The first patents on oil burners were for Russian steam-atomizing burners in 1866 and 1870, to Spakowski, Lenz, Artemev, and Urquhart. In this stove both fuel oil and water are allowed to drip together upon a hot metal dish wherein combustion of the oil and steaming of the water take place simultaneously, the gases being forced to pass between red-hot refractory bricks into a chimney-like stove, evidently producing enough draft to suck in the air necessary for combustion.

During the period from 1860 to the end of the first World War, about 1919-1920, domestic oil burning made very little progress anywhere in the world, while considerable use was being made of fuel oil for industrial purposes, in the Navy, on locomotives, and in large stationary steam boilers.

Fig. 2 is typical of the old American gravity-fed vaporizing-type burner, operating with natural draft, popular (if this term may be used) from 1920 until around 1932. The principle is simple and almost identical with that of the oil-vaporizing burners used in Rumania for burning heavy oil by letting it trickle upon hot plates with a crosscurrent of air. In this case, the draft was supposed to draw air through a hollow metal casting, heated by the flame itself, and to mix with vapors of the oil trickling down the slopes of a little volcano in the center.

Fig. 3 shows one of these burners installed in a round boiler. There appeared on the market scores of oil burners like these, and names such as Oliver, Vulcan, Waltham, Climax are familiar to every burner man whose task it was, sometimes as often as once a week, to remove the heavy top casting and clean the sooty mess which packed the whole apparatus. There was either too much draft and an unusually high consumption of fuel or a deficiency of air with its consequent formation of carbon. As soon as a little soot had been deposited on the oil passages, the entire equilibrium of the apparatus was destroyed and soot formed at an accelerated rate.

Contributed by the Fuels Division and presented at the Semi-Annual Meeting, Cleveland, Ohio, June 8–10, 1942, of THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS.

It was not until designers supplied a positive amount of air, under a slight pressure, by means of a fan, to the oil in the process of gasification, that domestic oil burners became a success. These pot-type burners made their appearance between 1922 and 1925, and many of them, such as the Kleenheet, Nokol, Laco, and Berryman are still in operation today.

MODERN VAPORIZING-TYPE BURNERS

Fig. 4 shows a modern version of the same principle, the Quaker burner. It would be wrong to believe that the vaporizing type of burner, wherein fuel oil is transformed into a combustible vapor by application of heat, has been replaced entirely by burners using other principles of oil preparation; they are indeed very much in favor today, especially for heating units of small size.

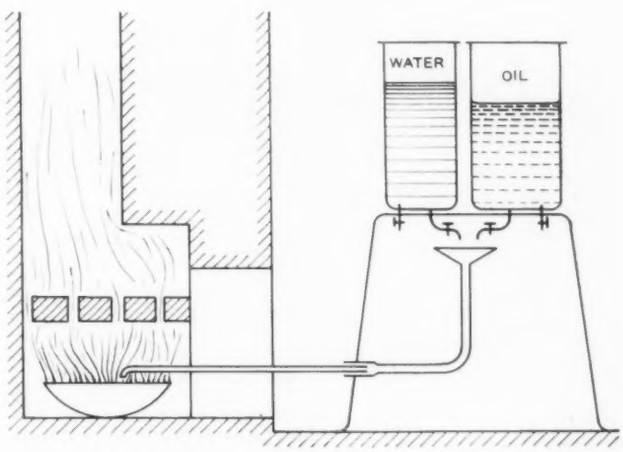

FIG. 1 THE ASTRAKAN STOVE

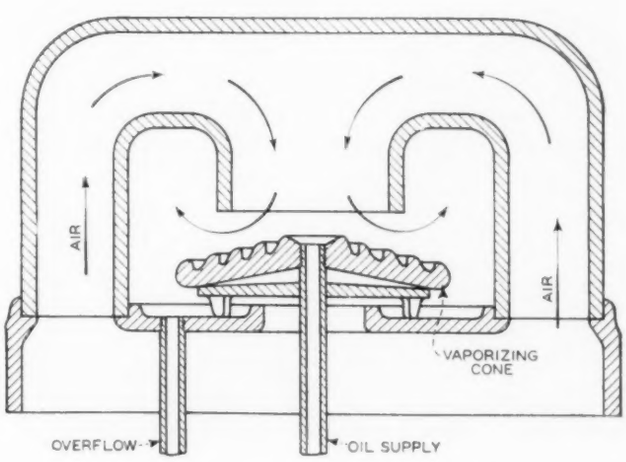

FIG. 2 OLD VAPORIZING BURNER

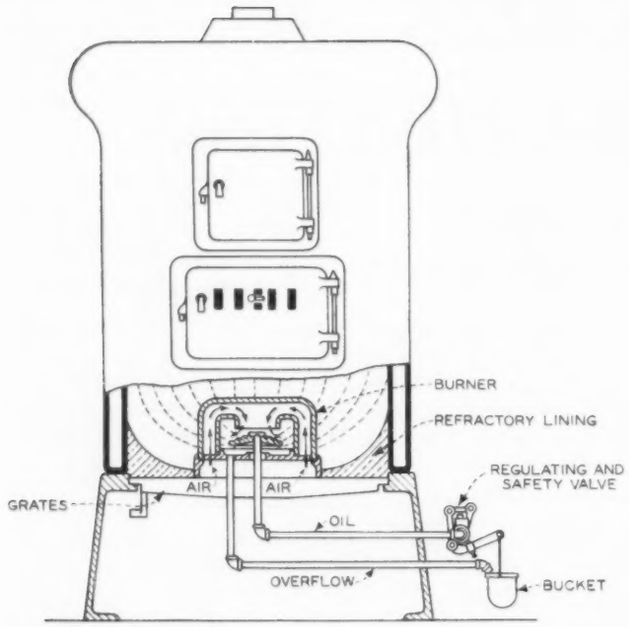

FIG. 3 OLD VAPORIZING BURNER INSTALLED IN A BOILER

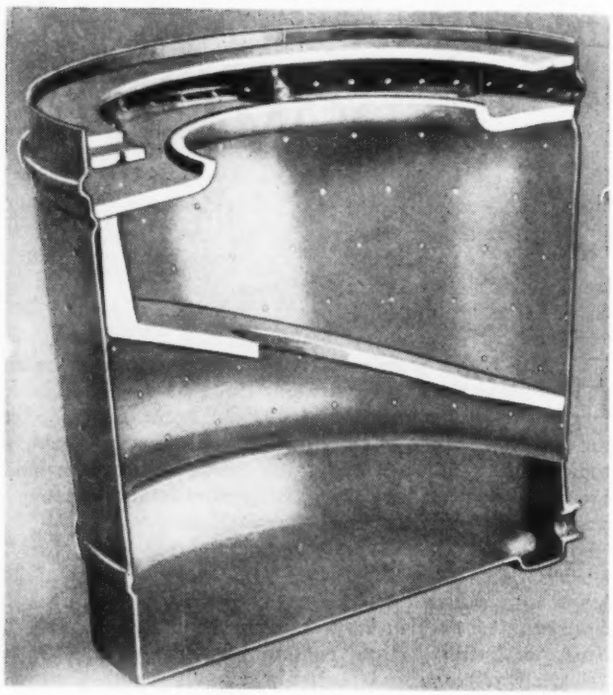

FIG. 5 DUO THERM VAPORIZING POT; VALJEAN PATENT

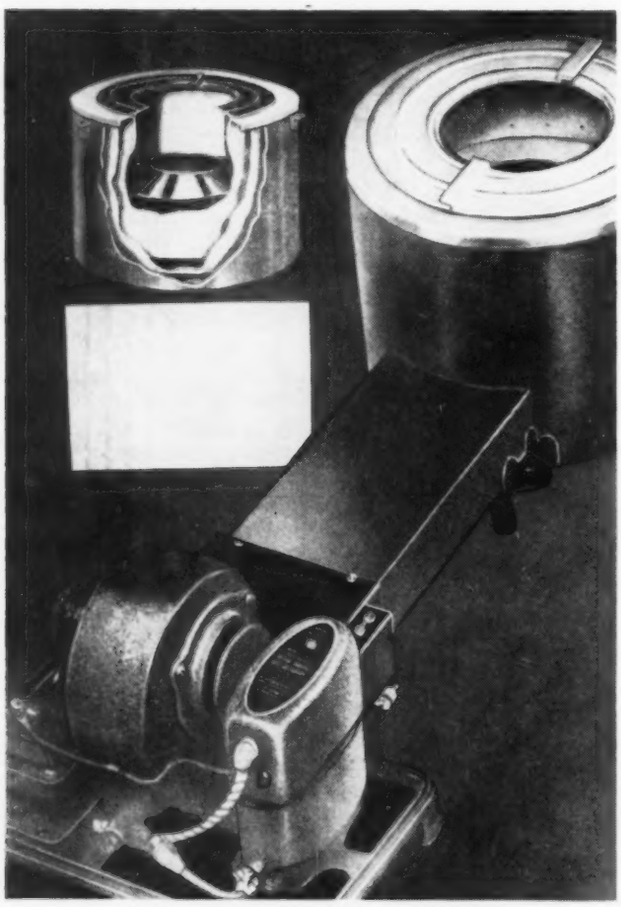

FIG. 4 MODERN VAPORIZING BURNER

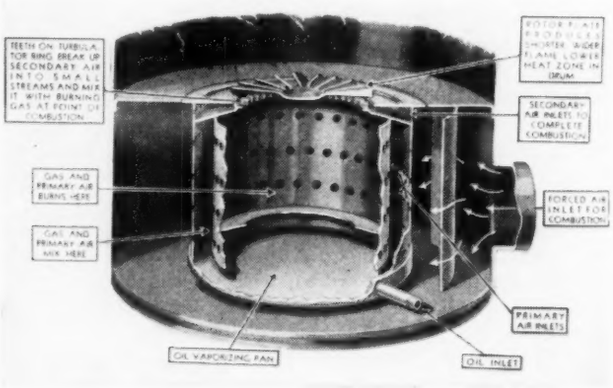

FIG. 6 THE MONOGRAM POT

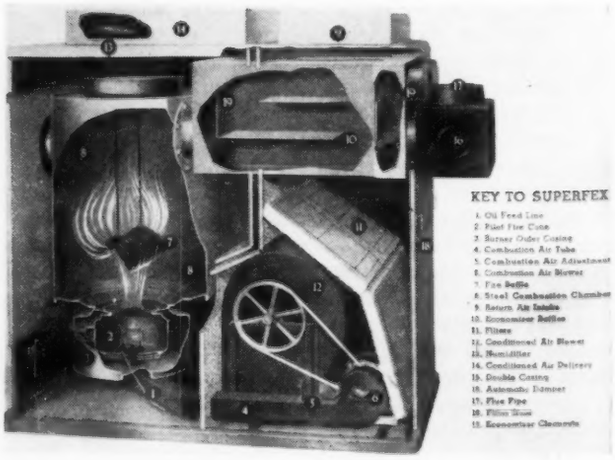

FIG. 7 AIR-FURNACE UNIT WITH VAPORIZING-TYPE BURNER

However, it is a far cry from the old trickling oil well, or from the smudge-pot burner used in the California orchards, to the well-designed well-baffled pot burner of today, in which a thorough and progressive mixture of air and oil vapor takes place, and which can be used with a low, a medium, or a high flame, such as the Duo Therm pot, a Valjean patent, shown in Fig. 5, or the Monogram pot of Fig. 6. The present successful use of the vaporizing-type burner must also be credited to a great extent to the improved mechanism for controlling the flow of the oil delivered by gravity to the oil-burning pot; it consists of a constant-level valve and metering valves for high, low, and medium flames.

The vaporizing burners of today are either used in heating units equipped with a fan supplying the air necessary for combustion, or depend only on natural chimney draft to draw in the air. Fig. 7 shows a complete Superfex air-furnace unit of the vaporizing type, while Fig. 8 represents a Monogram air unit designed for the utility room of a small house without basement. To illustrate one of the most popular modern ap-

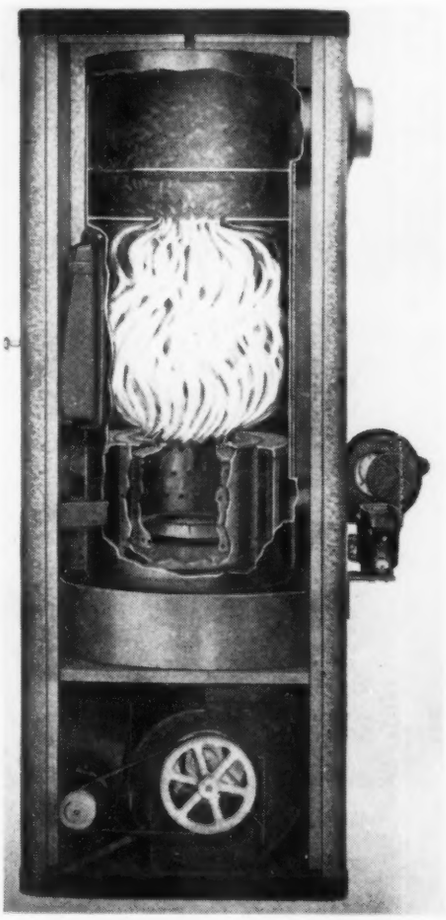

FIG. 8 UNIT DESIGNED FOR UTILITY ROOM

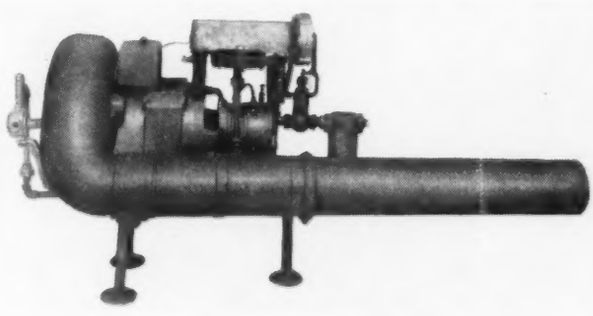

FIG. 10 AN OLD LOW-PRESSURE ATOMIZING BURNER

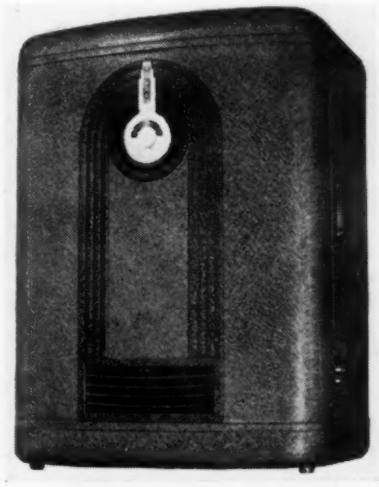

FIG. 9 MODERN OIL-FIRED SPACE HEATER

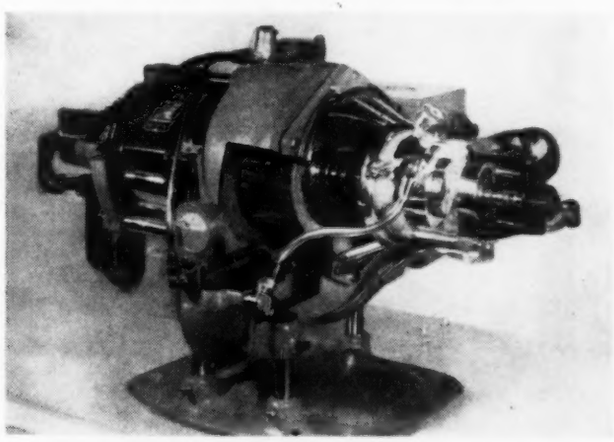

FIG. 11 THE JUNIOR OIL-O-MATIC

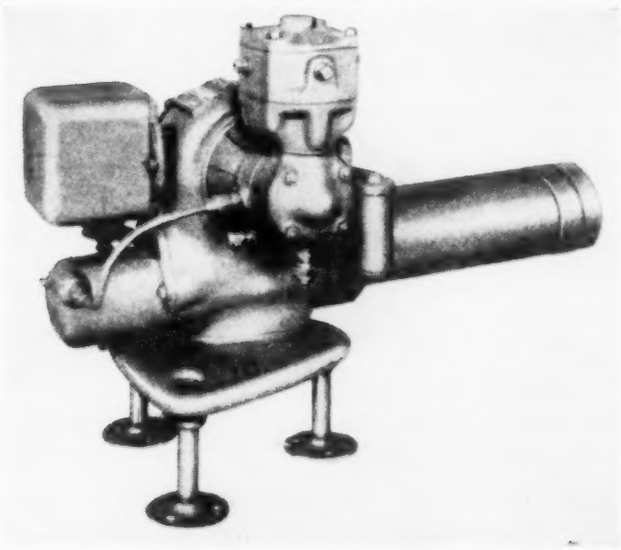

FIG. 12 MODERN LOW-PRESSURE ATOMIZING BURNER

plications of the vaporizing-type oil burner Fig. 9 shows a Coleman space heater, a type of oil stove of which millions have been sold during the last few years.

Obviously, when natural draft is depended upon to supply all the air for combustion, the same difficulty is met as existed 20 years ago, namely, a lack of co-ordination between the oil flow and the air supply. This is especially true when the burner operates at low fire and during the periods of rating increase when stack temperatures are too low to create enough draft to burn completely the rapidly increasing oil supply. Great care must therefore be exercised to avoid abrupt changes of oil flow, either by manual or by automatic control; also to avoid oil flows in excess of what the maximum input of air to the burner can handle without smoking.

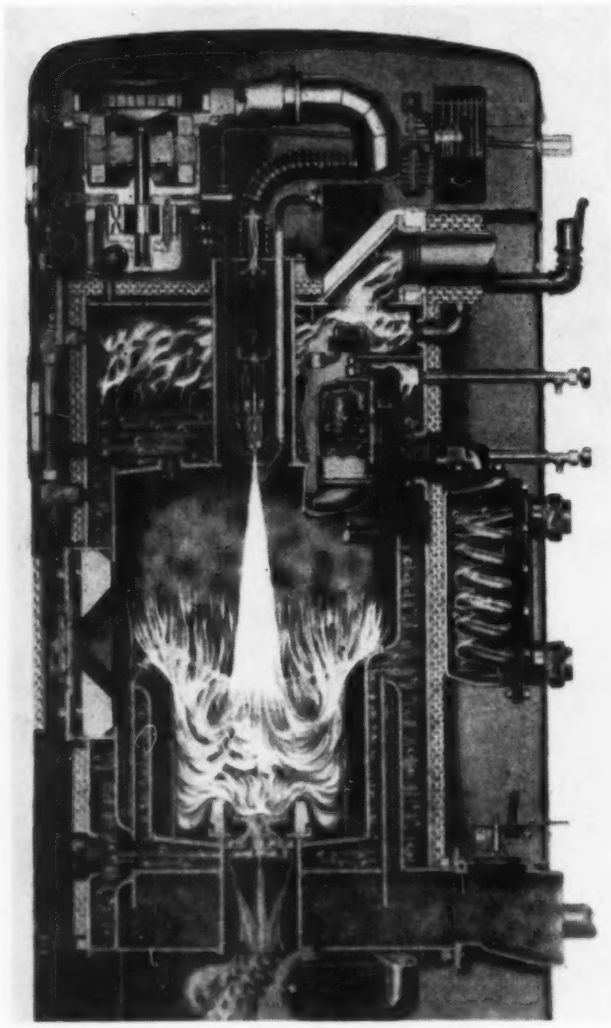

FIG. 13 SECTIONAL VIEW OF GENERAL ELECTRIC BOILER-BURNER UNIT; LOW-PRESSURE BURNER FIRING VERTICALLY DOWNWARD

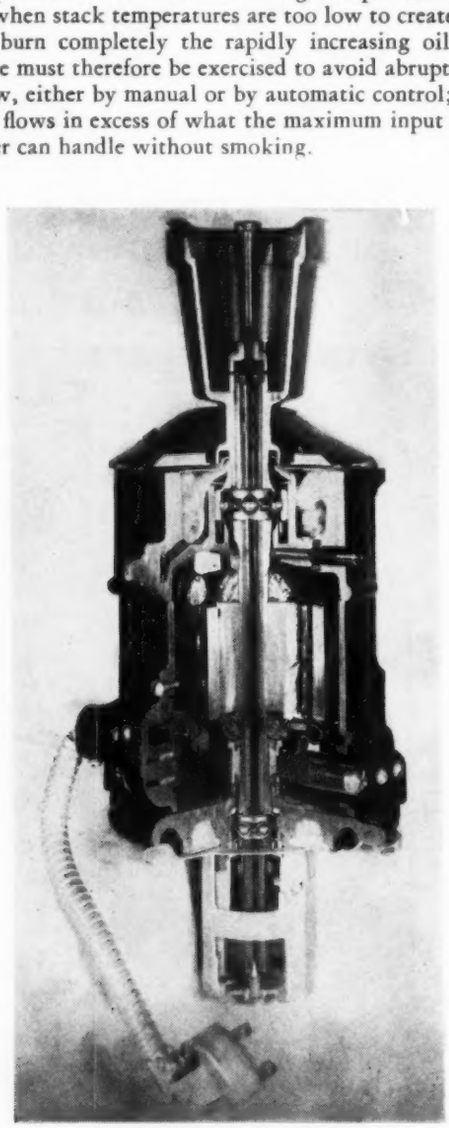

FIG. 15 SECTION OF A.B.C. ROTARY BURNER

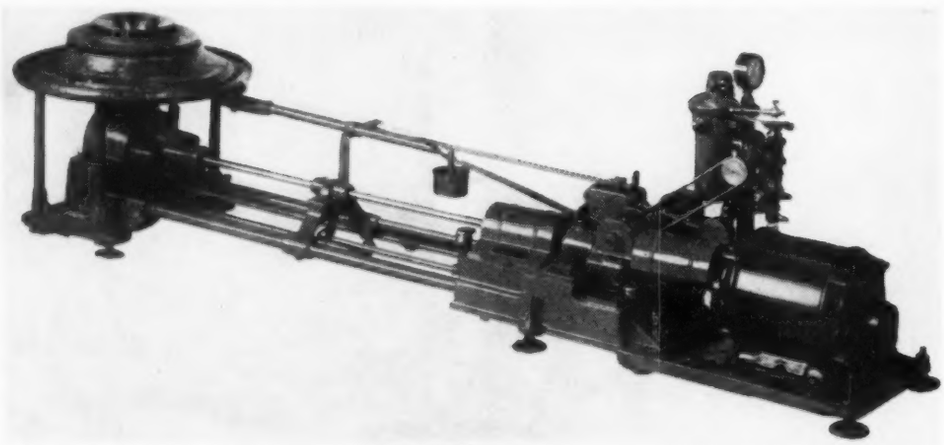

FIG. 14 VERTICAL ROTARY BURNER: THE HARDINGE

LOW-PRESSURE ATOMIZING BURNERS

About the time of the introduction of the improved pot-type power burner, a novel type of burner for domestic use appeared on the American market, namely, the low-pressure atomizing burner, of which an early model is shown in Fig. 10. In this burner a mixture of primary air and fuel oil is prepared in a "metering pump" and released as a spray through a nozzle, at a pressure that varies from 2 to 7 lb, while secondary air supplied by a fan completes combustion. Ignition of the mixture was obtained by a gas flame which in turn became ignited from an electric spark. In this illustration, the mechanism on the top shows some of the devices by which correct sequence and timing of these successive ignitions took place every time the oil burner started.

Fig. 11 illustrates the Williams Oil-O-Matic Junior, a rather complicated piece of machinery which was superseded shortly after by the simplified Oil-O-Matic, such as the K-3 shown in Fig. 12. It is of interest to note that the low-pressure principle of atomization in the Williams Oil-O-Matic burner has remained inherently unchanged during the last 20 years. In this burner, besides the possibility of regulating the burner capacity within rather wide limits, the comparatively large oil and air passages made possible by the low-pressure principle permit using a great variety of fuels with equal success.

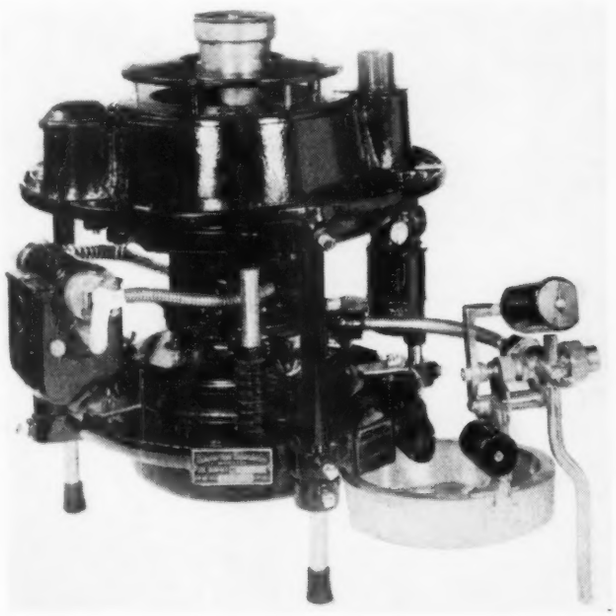

FIG. 16 ASSEMBLY OF A.B.C. BURNER

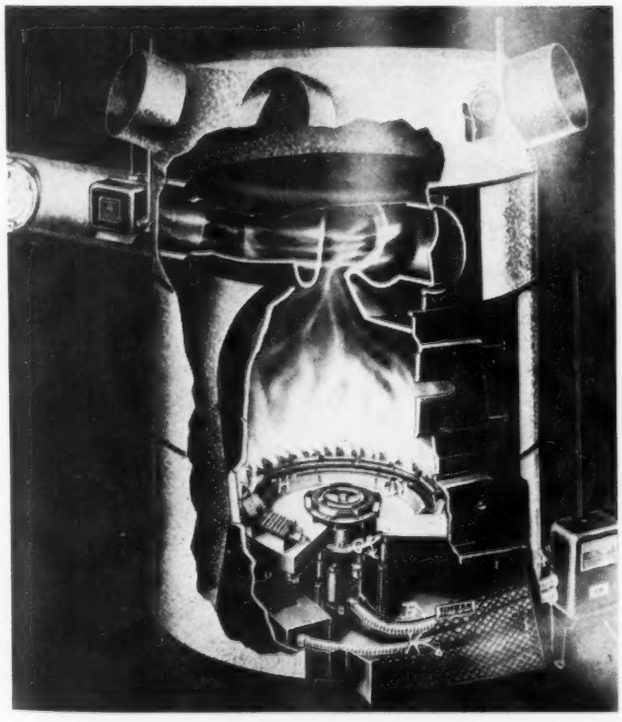

FIG. 17 ROTARY WALL-FLAME BURNER: THE TIMKEN SILENT AUTOMATIC

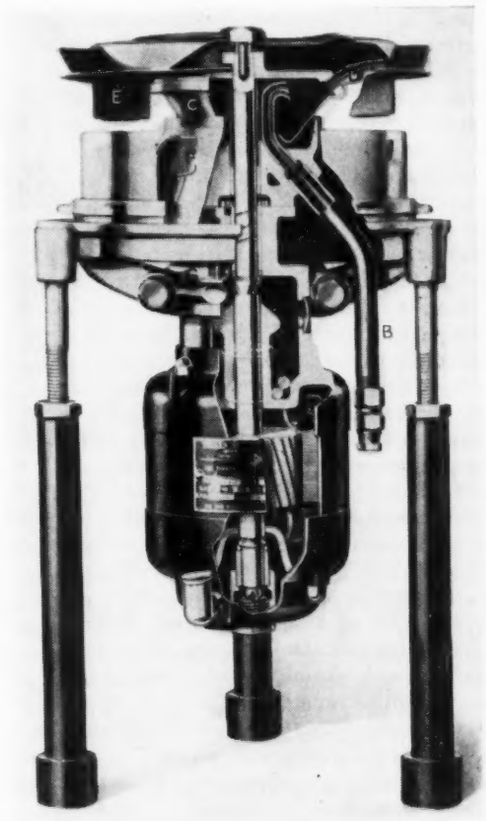

FIG. 18 SECTION OF TIMKEN BURNER

Other low-pressure atomizing burners are the Hart and the General Electric, the latter being best known in connection with the attractive General Electric burner-boiler or furnace-burner units, with downward firing, shown in Fig. 13.

VERTICAL ROTARY BURNERS

In the early 1920's there also appeared on the American market an entirely different principle of oil preparation, i.e., that of centrifugal atomization by means of a spinning burner rotating inside of the combustion chamber around a vertical axis. Fig. 14 illustrates one of the early applications of this principle, the Hardinge burner, of which many are still in successful operation today, the only drawbacks being some objectionable noise and the use of a gas pilot to ignite the fuel oil.

The principle of centrifugal atomization can best be followed in Fig. 15, which shows a cutaway view of a rotary A.B.C. burner, on which the oil-flow control, the spinner, and the air admission are easy to locate, extremely fine atomization being obtained by a rotating speed in excess of 10,000 rpm. The

entire assembly of the same burner is shown in Fig. 16, illustrating the easy removal of the entire burner from its seat. Another feature clearly visible in this illustration is the "trip pan," which was the safety feature of these early burners in case of lack of ignition. Even today, the simple principle of the trip pan or "trip-bucket" has been retained in a few burners.

While rotary burners such as the Hardinge, the A.B.C., the Sundstrand, the Commonwealth operated on the principle just described, and produced a flame shaped like a sunflower, about 1924-1925 the Silent Automatic Burner Company, absorbed by the Timken Axle Company of Detroit, developed a new principle called the "wall-wiping flame." Figs. 17 and 18 illustrate the Timken Silent Automatic wall-flame burner. In this unit, fuel oil is conveyed by gravity to a "spinning head" driven by a vertical electric motor located underneath the hearth of the boiler or furnace. The oil is sprayed by centrifugal force from this spinner, and mixed with air likewise induced from underneath the hearth by means of blades located on the spinner. Installed all around the periphery of the hearth and near the side walls of the boiler or furnace (hence the name of "wall-flame burner") is a ring especially constructed to receive the impact of the air and partly atomized oil mixture. A gas pilot or an electric spark, located somewhere along this ring, ignites the mixture and, after a few seconds of a rather mediocre combustion, the ring becomes heated to the point where it will "vaporize" the oil and air mixture, transform it into a combustible gas, and cause it to burn upward, very much like a gas flame, with a purple color. High combustion efficiencies can consistently be obtained with this type of burner when properly installed.

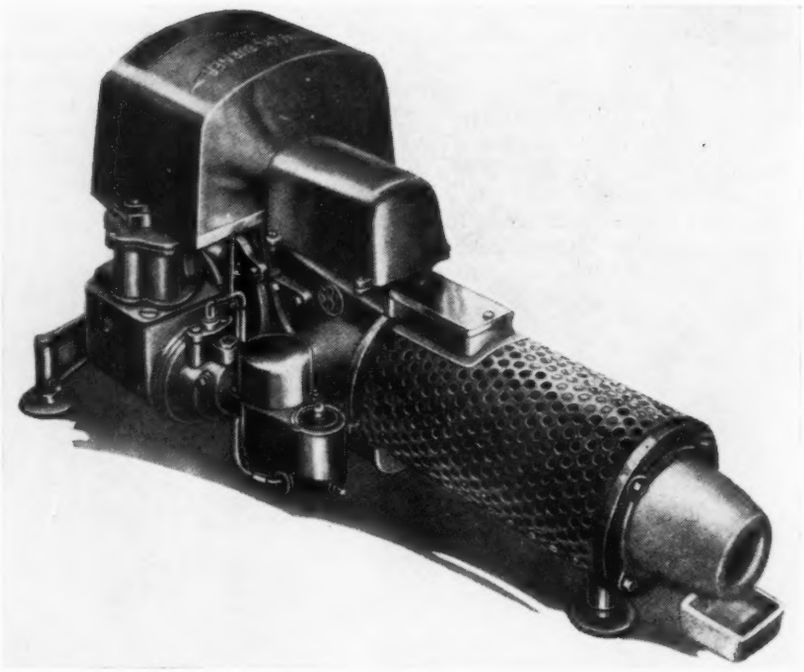

FIG. 19 AN OLD GUN-TYPE BURNER: THE SOCONY ARROW

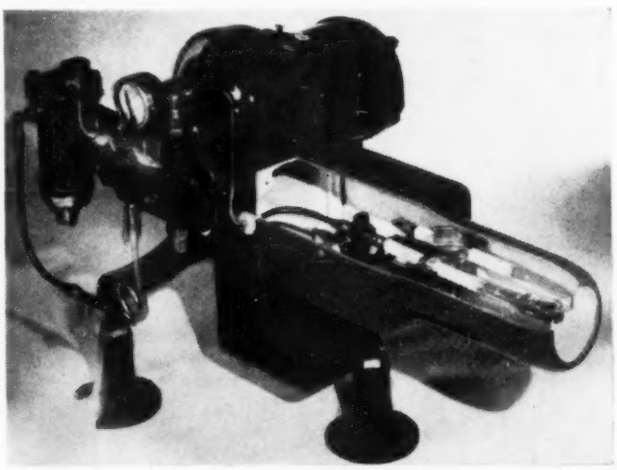

FIG. 20 SECTION OF HIGH-PRESSURE ATOMIZING BURNER

HIGH-PRESSURE ATOMIZING BURNERS

Up to this point no mention has been made of the simplest and, for the time being, most popular type of burner, comprising 63 per cent of all oil burners sold in 1941, i.e., the high-pressure "gun-type" burner.

This burner made its appearance on the market in 1924-1925, and one of its original embodiments was the Socony Arrow burner, shown in Fig. 19, which was the first one handled by the Timken Silent Automatic Company. A description of this type of burner can be followed in Fig. 20, where the main parts are clearly visible: the oil-pump assembly with its oil strainer and its pressure-regulating valve, the nozzle tube, nozzle tip, air fan, transformer and electrodes for electric ignition. In this type of burner, contrary to what was said for the "low-pressure" gun type, oil capacity cannot be varied except by changing the nozzle tip; any change in the atomizing pressure (most efficient at about 100 lb) changes the quality of the atomization and affects the good operation of the burner.

One of the latest versions of a compact, high-pressure atomizing, gun-type burner is illustrated in Fig. 21, by the Herco burner. Interesting is the "Visaflame" control, a sort of mechanical eye which acts as a safety control, shuts off the burner in case of flame failure, and regulates the timing of the spark.

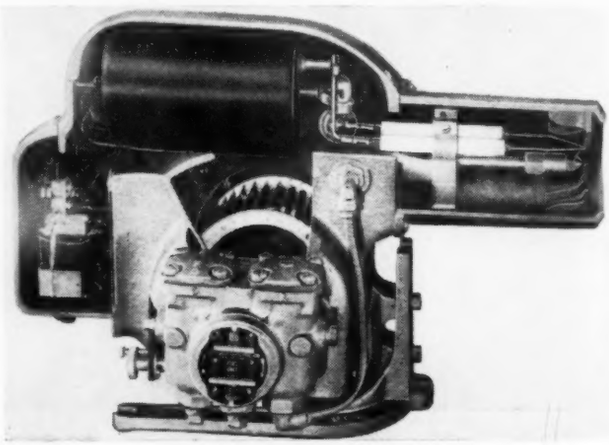

FIG. 21 MODERN GUN-TYPE BURNER WITH BUILT-IN ELECTRIC CONTROL

HORIZONTAL ROTARY BURNERS

Although burners of the horizontal rotary cup type are used mostly in larger units, of semi-industrial and industrial sizes,

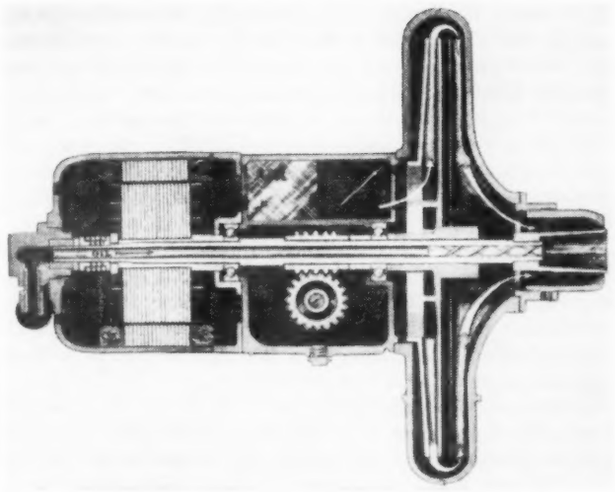

FIG. 22 HORIZONTAL ROTARY CUP BURNER

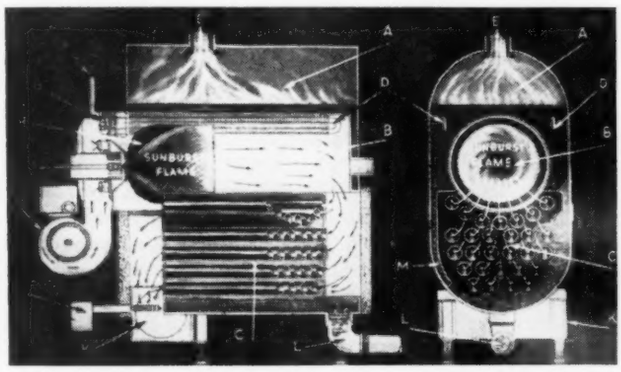

FIG. 23 SECTIONAL VIEW OF BURNER-BOILER UNIT

(*A*, steam chest; *B*, firebox; *C*, boiler tubes; *D*, submerged domestic water heater; *E*, steam nozzle; *F*, domestic hot water to taps; *G*, cold water to domestic water heater; *H*, fire bowl; *I*, model "O" burner; *J*, protecto-relay; *K*, opening to stack; *L*, return from radiators; *M*, water jacket.)

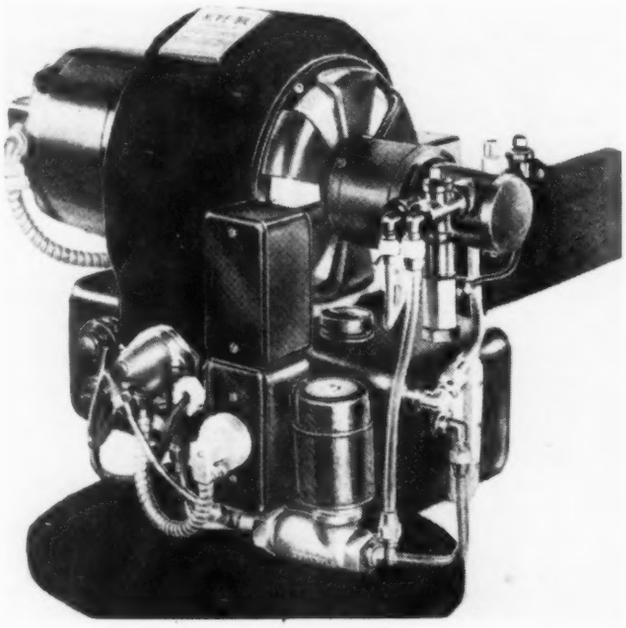

FIG. 24 DOMESTIC OIL BURNER DESIGNED FOR HEAVY FUEL OIL

small models are sometimes used for house heating. No review of domestic oil burners could afford to neglect them. Fig. 22 represents a section of an Ace burner with all its parts clearly visible and its principle quite obvious. Small sizes of Ray, Johnson, Midwest, Eds-Wil, Petro, and Enterprise burners, of the rotary-cup type, are being used for heating large homes using ordinary domestic fuel oil.

OIL-BURNING UNITS

A Garwood unit, a domestic burner as it appears on a boiler unit designed especially for oil, is shown in Fig. 23. It is generally admitted that, on the average, a saving in fuel oil of 12 to 15 per cent can be effected, with a unit purposely designed for oil, over a boiler or a furnace of the so-called "conversion" type.

DOMESTIC USE OF HEAVY FUEL OIL

During the last 4 years several burners have been put on the market for the purpose of utilizing the heavy fuel oil commonly classified as No. 5 oil, for domestic application. Fig. 24 shows one of these burners, i.e., the Hev-E-Oil burner. An electric heater, operating intermittently, conditions the fuel for use in the small combustion chamber of a domestic furnace or boiler, and for its electric ignition. These burners, Hev-E-Oil, Sav-Haf, Rayfield, and Gibson are quite successful mechanically but restricted in their use, because of lack of general distribution of No. 5 oil for tank wagon deliveries, and also because of the recent narrowing of the price differential between No. 5 fuel and the lighter grades generally used for domestic heating.

STEADY PROGRESS OF OIL HEATING

That domestic oil heating has experienced steady progress during the last 20 years is evidenced by the fact that, starting in 1920 with only a few models of oil burners, 179 different makes and types of oil burners were listed in a *Fuel Oil Journal* Recommendation Index of 1932, while today that same publication lists 1150 different makes and models of power burners.

There has been a steady increase in the oil-burner sales, year after year, climaxed in 1941, by a sale of 369,452 oil burners, bringing the number in use in the United States to nearly 2,500,000 units.

In 1941, the fuel oil supplied to these domestic burners amounted to nearly 120,000,000 bbl (an additional 45,000,000 bbl of heavy fuel oils were used for industrial heating).

APPARENT CAUSES FOR THE PROGRESS OF OIL HEATING

SAFETY AND AUTOMATIC OPERATION

One of the most apparent causes of this remarkable progress in oil heating seems to be the satisfaction of the domestic-oil-burner owner of today that his installation is completely safe; it is entirely automatic, and yet it is foolproof. This condition is due, primarily to the contribution made by the designers and manufacturers of automatic electric controls, whose equipment has reached a rare degree of perfection. Consider, in fact, what these controls will do today: They will automatically start and stop the motor of the oil burner, thus supplying the oil flow and the air flow necessary for combustion; they will automatically ignite the oil and air mixture, and stop ignition once the flame is thoroughly established; if ignition should fail, they will automatically stop the burner "on safety" to avoid any puffback, fire or oil flooding; likewise, they will stop the installation if, for any cause, the flame should fail (lack of oil, insufficient atomization, etc.); if the electric current stops temporarily, the automatic controls will prevent the burner from throwing oil into a hot furnace until proper ignition is re-established; they will start a pump circulating hot

water through the house; start a fan circulating warm air, and stop that fan to prevent cold air from creating an objectionable draft in the home; they will stop the burner if the temperature of the hot air or the hot water becomes excessive; in a steam boiler they will automatically feed fresh make-up water to the boiler, and stop the burner to avoid accidents if the level of the water should fall below a given mark; they will automatically maintain steam pressure between a maximum and a minimum specified, or permit vacuum to form if the system is designed for vapor heating. Automatically, they will maintain the temperature of the room where the thermostat is located within 2 deg of a set figure; automatically correct moisture may be maintained in the home. To all these automatic features can be added the fact that modern fuel-oil distributors see to it that their customer's tanks are kept well stocked with fuel oil, using temperature records for guidance.

COMPACT NEAT INSTALLATIONS

A second striking feature noticeable in oil-burning installations of today is their compactness, their neat appearance, and their almost noiseless operation, compared to the noise of burners of several years ago.

The current development of housing projects in the neighborhood of factories engaged in war production has given birth to a type of small packaged unit which can be installed in a utility room of a small house without basement, or, in certain cases, directly under the floor of one of the rooms, with natural warm air circulating, and a minimum of air ducts. Oil-fired hot-water boilers of reduced sizes are also extremely popular. In that connection, the fact cannot be too greatly emphasized that the care with which these small units are installed is even more important than their type or make. Too often low cost of installation becomes a governing factor, and the industry as a whole suffers as a consequence of the dissatisfaction of one small group of homeowners.

INCREASED EFFICIENCY

A third feature to which can be attributed the progress of domestic oil heating is a gradual increase in the efficiency of the installations. For many years, the author had occasion to run tests of domestic oil-burner installations in five states, and has also compiled data obtained by other members of the Fuel Oil Department of his company. In the summer of 1937, a report was submitted to various groups of engineers in the oil-burner industry showing the following results:

Conditions found in 281 installations.... Average CO_2: 7.35 per cent
Average flue-gas temperature: 599 F
After readjustments on 179 of foregoing.... Average CO_2: 9.35 per cent
Average flue-gas temperature: 549 F

During the winter of 1941-1942, the author was placed in an unusually favorable position to observe and test domestic-oil-burner installations in connection with the "War on Waste Campaign." Briefly, this campaign conducted in the Middle West, with the assistance of local radio stations, direct mail, and with the co-operation of burner dealers, consisted in inspecting and testing oil-burner installations with a view of reducing the owner's heating costs and chiefly in order to help conserve the fuel-oil resources of the nation. Some 500 installations were tested with the following results:

Conditions as found.....Average CO_2: 8.72 per cent
Average flue-gas temperature: 553 F
After readjustments..... Average CO_2: 9.16 per cent
Average flue-gas temperature: 503 F

These figures call for comment as follows:

1 Before any readjustments, an increase of 1.37 per cent in CO_2 and a reduction of 46 deg in the flue-gas temperature show that modern installations are considerably better than the average of 1936-1937. This is due partly to a better education of the burner people, partly to a greater number of packaged units actually designed for oil burning, but particularly to the wholesome effect brought about in the oil-burner industry by the "Commercial Standard Specification CS75-39," worked out by the Underwriters Laboratory, specifying certain reasonable minimum standards of efficiency which most burner people today seem to respect and often to surpass.

2 The highest flue-gas temperature recorded was over 950 F in an undersize round cast-iron boiler; the lowest (not counting installations of a certain type with heat economizers) was 330 F; the highest CO_2 reading was 14.5 per cent. Note that the theoretical CO_2 obtainable with a fuel oil used for domestic power burners is about 15.3 per cent.

3 In view of the condensation of the water vapor of combustion in the chimneys of oil-fired units enjoying a low flue-gas temperature, and the subsequent deterioration of these chimneys when poorly constructed, certain oil-unit manufacturers have recently decided to raise the flue-gas temperature to the detriment of efficiency. The author does not believe that this is sound practice and would much rather see an efficient unit with a flue-gas temperature below 400 F, and the obligation imposed on the architect and the builder to design a substantial chimney, properly insulated, lined with vitrified tile or similar protective liner, and possibly with a receptacle at the bottom for the storage and subsequent disposal of any deposit that may accumulate.

4 Once in possession of the CO_2 and flue-gas temperature readings, the stack loss can be determined with the help of a chart such as shown in Fig. 25. To this "stack loss" an arbitrary loss of 4 per cent is added for ground radiation and unaccounted-for losses, to conform with the average conditions

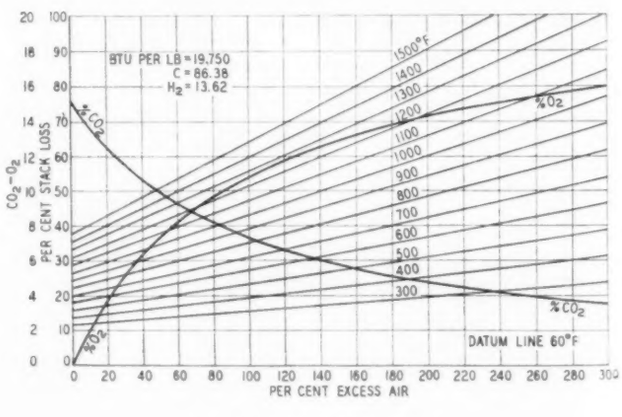

FIG. 25 STACK-LOSS CHART

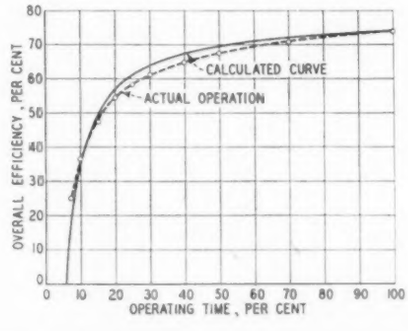

FIG. 26 CURVE SHOWING BOILER EFFICIENCY IN RELATION TO OIL-BURNER OPERATING TIME

obtained during carefully conducted laboratory tests. The total of the stack loss plus 4 per cent is deduced from 100 to obtain the "combustion efficiency."

5 It would be wrong to assume that this "combustion efficiency" tells the whole story of fuel economy in any given installation; the cycle of burner operation is of great importance. By that is meant the percentage of time that the burner is "on" during any 24-hr period. Oil-burner installations react quite differently when the burner is "off;" some cool off rapidly, others keep their heat well stored; the quantity of oil that the installation will need to compensate for these losses will naturally vary also. Tests conducted at the Sinclair Refining Company's laboratory prove that it is of advantage to keep the burner "on" for the longest period of time, for best economy. Tests from which the curve, Fig. 26, was plotted, led to the following conclusion: If any burner is installed to run constantly during the coldest day of the year, the weather conditions in the Middle West are such that the burner will, as an average, operate 20 to 30 per cent of the time; its efficiency will be nearly 10 per cent below what it would be if operating 100 per cent of the time. In summer, if any burner is equipped to produce hot water, it would be of advantage to reduce the oil flow (oil valve or nozzle) to increase the length of each operating period for better operation.

MOST FREQUENT NEEDS FOR READJUSTMENTS

It has been mentioned that, during the "War on Waste" campaign conducted in the Middle West, readjustments were being recommended as a result of the tests. It may be of interest to review briefly what these readjustments have been. In that connection, it must be made clear that all recommendations made to oil-burner owners should be of such a nature that the readjustments will be simple, inexpensive, and will cast no bad reflection upon the burner people who installed the job. In order of their decreasing frequency, the following summary of these readjustments is given:

(*a*) *Change of Draft and Air Supply.* Ordinarily, the change of draft and air supply to the burner is accomplished in one operation. It is frequently recommended to install "an automatic draft adjuster," such as illustrated in Fig. 27, when there is none present. It is felt that such an apparatus, designed to maintain a constant minimum draft, is advantageous in every installation that is not, by its very construction, absolutely airtight. In certain cases, installation of a special "chimney cap" has been recommended for downdraft conditions.

(*b*) *Tightening of Doors and Other Air Leaks.* A combination of leaky unit and high draft, together with a smoky fire and a low CO_2 is a very frequent occurrence, one which can most simply be remedied, often with spectacular savings and complete smoke elimination.

(*c*) *Cleaning the Burner.* The burner and especially the air inlet should be cleaned annually. Lint will accumulate frequently upon the fan blades. Oil filters and nozzle tips must occasionally be cleaned.

(*d*) *Change of Oil-Nozzle Tips.* Oil-nozzle tips require changing, either because the present nozzle was originally of the wrong size (generally too large), or because it has become worn out and is now admitting more fuel than is necessary. This change entails a readjustment of the oil pressure, and also of the air. Careful thought must be given to local conditions before recommending a change of nozzle tip; in particular the question must be considered whether it is better to raise temperature quickly in the home at the expense of some efficiency, or to allow for longer operating periods and better economy, at the risk of a more sluggish heat pickup. Here again, the "cycle" of operation, previously mentioned, is quite important.

(*e*) *Baffle Installation.* A baffle might be installed over the combustion chamber; for instance, the milking-stool type illustrated in Fig. 28, or baffles in the gas passages, for better heat absorption by the boiler or furnace. In some cases a rebuilding of the combustion chamber may be indicated, to follow modern practice. This includes both modern sizes and shapes, and modern materials, such as heat-insulating brick. Tests recently conducted at Iowa State College indicate average fuel savings of 5 per cent with this type of brick over ordinary refractory construction.

FIG. 27 AUTOMATIC DRAFT ADJUSTER

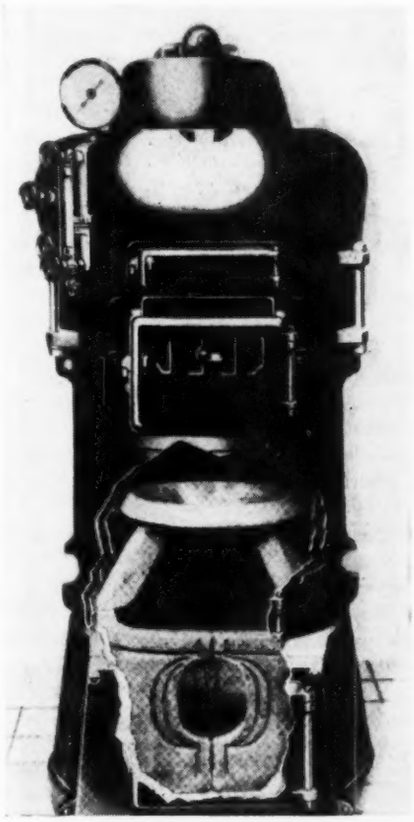

FIG. 28 TRIPOD REFRACTORY BAFFLE

(*f*) *Pulsations.* A problem which comes up very frequently during inspections is that of "pulsations," either continuous or occurring only when the burner comes "on" and "off," especially in modern furnace units.

Considerable research work has been conducted during the past two years in an effort to contribute to this study of pulsation, but at the present writing only the following negative results can be reported:

1 While it was originally believed that pulsations were caused primarily by an incorrect mixture of the oil spray and

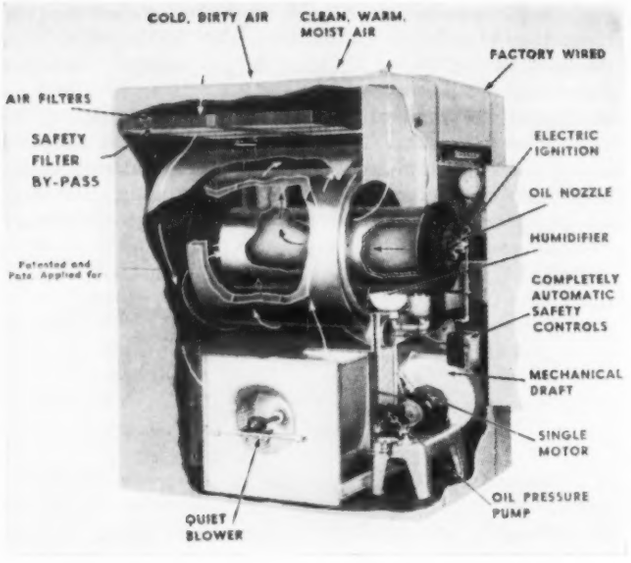

FIG. 29 A FURNACE UNIT WITH "INDUCED" AIR

the air flow at the burner outlet, experiments have shown that they may occur regardless of how intimately, evenly, and uniformly the oil-and-air mixture is produced.

2 Changes in the shape or size of combustion chamber, or the furnace space immediately above it, do not necessarily eliminate pulsations.

3 Changes in the chimney draft, either in intensity or regularity, do not necessarily eliminate pulsations.

4 Pulsations may set up in a furnace regardless of the temperature of the furnace, either when the burner starts and stops, or during consistent burner operation.

5 It has been demonstrated that the addition to the fuel of an "antiknock" compound such as tetraethyl lead, which makes combustion more uniform in a spark-ignition engine by retarding combustion of the more easily ignitible products, does not eliminate pulsations in an air furnace.

6 Pulsations will not necessarily stop when the excess air is varied at the burner, neither will increased air pressures at the burner in all cases eliminate pulsations.

7 The shape of the connection between flue pipe and chimney will not cause or eliminate pulsations.

8 An air vent in the combustion chamber, permitting temporary excess gas pressures to be vented out, and allowing secondary air to be admitted, will always stop pulsations, but this expedient usually reduces efficiency and creates a risk of gassy odor.

9 Drawing the air and the products of combustion through the unit by a strong suction at the flue pipe, instead of blowing the air through the burner, will ordinarily eliminate pulsations. In this connection, Fig. 29 illustrates a Norge unit which uses that principle; a slight drawback is the hissing noise of the air. It is felt, at the present status of the work, that pulsations are not caused by any given condition but by any number of causes, the most likely being the very design of the gas passages through the furnace. If these gas passages could economically be made "streamlined," one of the most frequent causes of pulsations would be eliminated. Considerable work is still needed before some satisfactory answer to the "pulsation" problem, in general, can be given.

FURTHER IMPROVEMENTS RECOMMENDED

When inspecting a home heated with an oil-burning furnace, many further recommendations can ordinarily be made to the owner, which will improve the comfort, the cleanliness, and the economy of the heating system; for instance:

Partial or complete insulation of the home (including storm windows, weather stripping, etc.).

Better humidity control for more comfort and better health.

Relocation of the thermostat; sometimes replacement with a new model.

Installation of a circulating pump or a circulating-air fan.

Sometimes a change in the temperature settings for the aquastat or the fan control.

Cleaning or replacement of the air filters; sometimes tightening of leaks between air ducts, grilles, and walls.

Checking radiators; recommendations of special valves for more even heat distribution; elimination of air.

END OF A TWENTY-YEAR ERA

It is difficult to predict what the future holds in store for the oil-burner, as well as the fuel-oil, industries. While it does not appear likely that a shortage of fuel oil will force present owners of oil burners to replace their units with some other apparatus adapted to another fuel, no great encouragement will be given, until after the war, to the oil-burner manufacturers, in order to save simultaneously the precious metals that constitute the burners, and the fuel oil which may become necessary for Diesel engines, or for other purposes connected with our war effort. The oil-burner concerns will accept these sacrifices with equanimity and stoicism.

It may therefore be that 1942 will close a 20-year period of spectacular progress in domestic oil burners, from the first World War to the present one, and that new concepts in the art of heating with oil will mark the beginning of a new era—the era following our costly, slow, but nonetheless certain victory.

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The DYNAMICS *of* INDUSTRIAL DEMOCRACY[1]

By JOHN LANDGRAF

MASSACHUSETTS INSTITUTE OF TECHNOLOGY

THIS is an important book.[2] It is a book that should be read by many more than those who are interested in industrial relations only. It is a book that should be discussed and considered in the light of the American scene. Its readers should think about it and its implications as they read their morning newspapers.

To say these things about a new book means very little, for few books that are reviewed have very much less said about them. It is a difficult task to define, and to make stick, why this particular little book of 350-odd pages should be more important, should have such wide and significant bearing on the contemporary scene. To this reviewer there is an almost fanatic urgency that as many "educated" people read it as possibly can. The presently reviewed copy has already been virtually forced on some half-dozen individuals, the title on many others. The "victims" apparently have been likewise impressed. Let the reviewer make clear why he feels as he does.

The volume is the work of two members of the Steel Workers Organizing Committee (C.I.O.). One, Golden, is an older, experienced, and "practical" man; the other, Ruttenberg, is a younger, more "theoretical" man. They deal primarily with the role of their union in the industrial scene of the past few years, taking examples from their files and from personal experiences. They begin the book by enunciating thirty-seven "principles" of effective union-management relations and go on to enlarge upon and to illustrate each of these throughout the volume. The principles are so arranged that, as they are dealt with, the material leads from the more particular union material into the more general "social" view of American industry and its relation to the world.

TECHNIQUES DEFINED

The book seems important to the reviewer primarily, probably, because it satisfies to some degree that almost universal feeling that so many of the techniques that we see others using never seem to get defined so clearly that the rest of us can understand them or use them. We see attempts at definition; but often it seems that those who write the books or articles on new subjects are the ones who see only a small and exclusive aspect of the whole. Descriptions are written frequently as small, very theoretical treatises, apparently impracticable, and certainly not understandable or available without considerable background; or the description is treated with such journalistic detachment that it has no life or "realistic" appeal.

Here is a book not written by scientists, hardly quoting the few "professional" works that now define the specific field it deals with, certainly unaware of the scientific works that deal with its wider implications. Here is a book, too, not written by journalists or professional writers who seek to "interpret" or "color" something new and obviously important. We deal with no Stuart Chase or Paul de Kruif. The writers are men who deal, and have dealt for years, with the bulk of the things that they write about. They write with a wealth of practical and personal detail that makes one read perhaps with a shade too much haste, as if reading Conrad or a good detective story.

Yet here is a book that gives adequate definition to one aspect of a larger idea, with full realization, apparently, of the larger implications present. The writers believe sincerely in what they talk about and have also a keen appreciation of the realistic position of their idea. It is all of this that makes their book of such wide interest, outside of what appears to be its special field.

This, then, is the first reason for the importance of the book. It gives a clear exemplification in the American industrial scene of what the psychologists call "participation," the feeling on the part of the individual that he is actually *taking part* in what is going on. And the authors feel fully the political and social importance of this view for the world as a whole.

"ECONOMIC MAN" MUST DIE

A second reason for the importance of "The Dynamics of Industrial Democracy" is that it documents so beautifully the necessity for the death of the "economic man," who unfortunately, is not yet dead completely in the world visions of many men on both sides of the picture in American industry; indeed, the gentleman is not yet dead in the minds of many men with power in other aspects of human organization, in government, in religion, in science. There are still many managers who have "done everything" for their employees, "coddled them," who cannot understand the active "ungratefulness" of the men who work for them. There are those who blame the whole thing on a government administration or violent men with peculiar idealogies. And there are union leaders who feel that the only way that they can keep their seats and maintain their organizations is to keep on getting a progressively higher hourly wage or better toilets for their union members. Here is how the authors feel about all of this:

> To look upon industrial unrest and the formation of labor unions as springing primarily from economic factors is an over-simplification of the problems of human relations. The basic needs of the human beings who make up American industry's working force are threefold:
>
> 1 Economic—an adequate plane of living and the necessary amount of job and wage protection.
>
> 2 Psychological—the personality needs of freedom of action, self-expression, and creative outlets.
>
> 3 Social—the ties and bonds of group relations and community life.

It seems to this reviewer that here is the simple expression of principles that modern social science is only just beginning to be definite about. Here is a simple expression of principles that any successful leader, military, political, religious, or otherwise knows, and uses intuitively in his work.

A third and more particular reason for thinking this book

(*Continued on page 743*)

[1] One of a series of reviews of current economic literature affecting engineering prepared by members of the department of economics and social science, Massachusetts Institute of Technology, at the request of the Management Division of The American Society of Mechanical Engineers. Opinions expressed are those of the reviewer.

[2] "The Dynamics of Industrial Democracy," by Clinton S. Golden and Harold J. Ruttenberg, Harper & Bros., New York, N. Y., 1942.

This book was also reviewed by J. M. Juran in the August issue, pp. 623–624.—EDITOR.

IONS, PARTS PER MILLION, *and* EQUIVALENTS PER MILLION[1]

FOR about 80 years, water chemists have been trying to express the results of water analysis, and during that time, many schemes have been published and used. A person unfamiliar with these schemes must have at his elbow both a chemical dictionary and a handbook to translate data into terms taught him during his college chemistry days. The published literature supplying water-analyses statistics, as well as text and handbooks, shows the extremes to which this situation is carried. For example, systems in current use present the data as: parts per million; parts per hundred thousand; Clark degrees; German degrees; French degrees; in terms of calcium carbonate; grains per U. S. gallon; grains per Imperial gallon; grams per liter; per cent of normal; and mille equivalents per liter. The substances are sometimes reported as ions, sometimes in terms of hardness, and at other times in terms of calcium carbonate, and as oxides or salts. Then, to supply a more complete (?) picture, the results are reported in terms of compounds as the individual analyst "thinks" they are present, and the report is thus labeled most properly, "Probable or hypothetical combinations."

RATIONAL SYSTEM STANDARDIZED BY A.S.T.M.

A rational system for reporting the results of analysis of water has been standardized by the American Society for Testing Materials, on recommendation of Committee D-19 on Water for Industrial Uses. This committee, which includes in its membership men conversant with both domestic and industrial uses of water, has recommended that the results of water analysis are to be expressed in the ionic form, that the values be expressed in parts per million (ppm) by weight, and further, that for evaluating the analysis, they be expressed in equivalents per million (epm). The committee's views on this subject are well expressed by R. C. Adams (1),[2] in the paper, "Reporting the Results of Water Analysis." "In the field of water treatment," Mr. Adams states, "there is no common language in which the results of water analysis are reported. Within small groups mutual understanding has been achieved by definition and standardization of the terms used, but when a member of such a group speaks to a larger audience he must either restate his definitions or trust that his audience can translate for themselves with the aid of dictionary or conversion factors." He asserts that any common method of expression should meet the following requirements: "It also should be convenient to use; it should provide the means for simple calculations and, most important in a scientific method, it must be concise. . . . The analyst must be able to report what he actually finds—what really is in the sample, not hypothetical similarities."

In discussing the reasons supporting the method of expressing analytical results (later adopted by the A.S.T.M.), Adams said:

> According to the proposed method, the concentration of material dissolved in water will be reported in either or both of two units—parts per million and equivalents per million. A part per million equals one milligram per kilogram of sample, or one pound per million pounds of water. In such dilute solutions as ordinary industrial waters, it is indistinguishable from one milligram per liter, but in reporting the analysis of brines, reagent solutions, or other concentrated solutions, the specific gravity of the sample must be considered. An equivalent per million is a gram equivalent weight per million grams of solution. Both are accurate weight per weight units, not dependent on the specific gravity of solution.
>
> Parts per million is a convenient unit for measuring the gross amount of material dissolved or suspended in a water sample, or for measurement of this total. It is an awkward unit to use for calculation of dosages or the products of reaction, because the molecular weight or even fraction of the molecular weight of each constituent must be used in each portion of the calculation. By converting all ionic concentrations to equivalents per million the reaction calculations are simplified to addition and subtraction.

"A widespread practice of reporting molecular combinations," said Mr. Adams, "is undesirable because such a report

TABLE 1*A* HYPOTHETICAL COMBINATIONS IN PARTS PER MILLION (3)

Method	1	2	3	4	5	6	7	8
Silica	12.0	12.0	12.0	12.0	...	12.0	12.0	12.0
Free CO_2	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0
Ferrous iron	...	1.2	1.2	1.2	...	...	1.2	1.2
Calcium carbonate	87.4	71.8	87.4	71.8	...	73.6	87.4	73.8
Calcium bicarbonate	...	...	...	...	141.0	...	...	...
Calcium sulphate	...	21.2	...	21.2	...	18.5	...	18.5
Calcium nitrate	...	...	...	...	...	0.3	...	...
Magnesium carbonate	22.0	23.9	10.7	23.9	...	33.6	22.2	33.6
Magnesium bicarbonate	...	...	...	...	17.3	...	...	...
Magnesium sulphate	16.6	...	14.4	...	18.7	...	16.4	...
Magnesium chloride	...	10.8	...	11.0	2.0	...	...	...
Magnesium silicate	...	...	...	...	10.4	...	...	...
Magnesium nitrate	...	0.3	...	...	...	...	...	...
Ferrous carbonate	2.5	...	...	...	1.2	2.5	...	...
Sodium sulphate	2.6	...	...	...	...	2.9	2.9	2.9
Sodium chloride	23.1	9.8	23.1	9.6	20.7	23.1	23.1	23.1
Sodium nitrate	0.3	...	0.3	0.3	0.3	0.3	...	...

TABLE 1*B* FUNDAMENTAL ANALYSIS IN PARTS PER MILLION (3)

Total solids	196
Total hardness ($CaCO_3$)	117
Carbonate hardness ($CaCO_3$)	100
Noncarbonate hardness ($CaCO_3$)	17
Magnesium	9.7
Calcium	35
Sodium and potassium	10
Ferrous iron	1.2
Bicarbonate	122
Chloride	14
Nitrate	0.25
Sulphate	15
Silica	12
Free carbon dioxide	2

TABLE 1*C* ANALYSIS IN 1*B* PRESENTED IN A.S.T.M. STANDARD PROCEDURE

	Ppm	Epm
Dissolved solids	196	...
Free CO_2	2	...
Silica	12	...
Calcium	35	1.75
Magnesium	9.7	0.80
Sodium	10	0.43
Ferrous iron	1.2	0.04
Bicarbonate	122	2.00
Sulphate	15	.31
Chloride	14	0.39
Nitrate	0.25	0.004
Total hardness	...	2.3
Carbonate hardness	...	2
Noncarbonate hardness	...	0.34

[1] Prepared by Max Hecht, chairman, A.S.T.M. Committee D-19, on Water for Industrial Uses.

[2] Numbers in parentheses refer to References at end of paper.

is not an accurate representation of the analyzed sample. In solution, all salts are dissociated into ions; analytical procedures determine either individual ions or groups of ions of similar electrical signs, so that if the analyst reports what he actually determines, he should report ions. A report of molecular combinations must be calculated from concentrations of the ions, and the nature of the report will be influenced by the opinion of the calculator, so that reports of analysis of identical samples by different laboratories might not be recognized as the same."

To illustrate the points stressed by Adams, eight chemists were supplied with an analysis of Lake Erie water. The reported results of their calculations are shown in Table 1*A* (3). It is immediately apparent that we have the confusing picture of three apparently different types of water derived from the one fundamental group of data in Table 1*B* (3). According to the method now standardized by the A.S.T.M., "Reporting the Results of Analysis of Industrial Waters, D596-41 (2), the fundamental analysis would be calculated in terms of equivalents per million as shown in Table 1*C*.

PRACTICAL ADVANTAGES OF STANDARD METHOD

The standard method is complete and concise. It provides essential definitions of the terms used. It specifies the use of ionic terms. It contains the necessary conversion factors for calculation of the results from parts per million to equivalents per million.

The technical executive, whose knowledge of chemistry has grown rusty, when presented with the results of water analysis conforming to A.S.T.M. procedure, may be able to arrive at speedy decisions concerning the suitability of the available water supply for the process in hand and can more easily establish specification requirements for water-processing equipment and operation.

The conclusions of the analyst are not subject to misinterpretation which is secured from reports of probable combinations.

Technical articles using the system are easily interpreted, if authors follow the A.S.T.M. procedure in the presentation of data based on water analysis.

It is suggested that in the development of A.S.M.E. test codes and in the revisions of existing ones, the A.S.T.M. procedure be employed in instances where water and its quality are specified.

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3 Report of Power Stations Chemistry Committee, Part 2, Publication No. 289-114. A serial report of the Prime Movers Committee, N.E.L.A., issued by Edison Electric Institute, New York, N. Y., 1929. Tables 1*A* and 1*B* from page 10. This report also supplies factors for water treatment reactions in ionic form. See Table 3, p. 9.

The Dynamics of Industrial Democracy

(*Continued from page 741*)

important is concerned with its more particular subject. It is a union book, written by union men, defining their views of what a union does, what it should be, and what it can be. The union concept is still an extremely emotional and controversial aspect of our lives, particularly emotional to those who deal with industry directly. We have to live with unions. They now seem to be an integral part of our national life, a "custom of the country." Apparently, the unions are now becoming a legally recognized part of government policy, certainly, in the point of view of this reviewer, they have become a part of the workingman's view of industry. Whether or not a single individual can see unionism in his own mind as a part of the industrial scene that he deals with, he yet has to face on a reality level the fact before him. He has to deal with unions. Here then is good information about what unions would like to see, what progressive unions would like to see at any rate. The authors are well aware that they represent only a small portion of union leadership. They discuss that question realistically. They give good reasons for their minority position.

On the negative side there are several objections that can be raised to the work, in spite of its admitted importance. The men who write are not specifically trained in observation. Their thirty-seven concepts are not actually thirty seven. Many are actually restatements or corollaries of others. While several of the principles may be partially true, they betray hasty assumption. The fact, for instance, that some men possess more ability for handling labor relations than others is much more true than that "salesmen and purchasing agents usually possess a more natural ability . . ."

These methodological points though, do not obscure the pertinence of the volume. With all their methodological aptness few professional men could show such insight.

BOOK OUGHT TO BE READ

For all these reasons then, this book ought to be read. It ought to be read by everyone who speaks about the "role of the unions" and it ought to be read by everyone who feels anxiety about democracy and what it can do in the world. It should not only be read in connection with the industrial life of America, but it should be read in connection with the failure of the Malays to help the British and Dutch in the East Indies, it should be read in connection with the history of the fall of France, the resistance offered by Russia.

Metals Salvaged From Ashes

ASHES taken from two process-steam boiler pits in the salvage department's shop are yielding critical materials at one of the General Electric Company's major works.

Shop refuse and rubbish from all parts of the works are used for fuel. Ashes removed from the boiler pits are passed through a ball mill, or grinder; a magnetic separator, which separates the ferrous from the nonferrous metals; and a concentration table which sorts out the finer particles. Metals reclaimed by this method include iron, steel, brass, copper, and aluminum. In 1941 a total of 624,000 pounds was recovered, representing a gross cash return of $10,000.

Other items, which in the past have been unsalvageable economically, are yielding critical materials in quantities that are worth while in these times. For example, the salvage department receives from the wire-drawing department a waste known as "copper and grease." It is taken from the pits under the wire-drawing machines and consists of a mixture of wire-drawing compound and fine copper particles. The wire-drawing compound is in liquid form and contains water, soap, and tallow which is applied to the drawing dies for lubrication and cooling. This flows into a pit underneath the wire-drawing machine and carries with it fine pieces of copper. It is shoveled from the pit into steel drums and when the water and grease are removed, the copper remains in dry, hard chunks. Last year 88,200 pounds of copper reclaimed in this way were shipped out to the smelters and vendors for conversion into raw materials. Gross return: $8000.

COMMENTS ON PAPERS

Including Letters From Readers on Miscellaneous Subjects

Kinematics and Mechanisms

COMMENT BY E. S. AULT[1]

The author has presented a concise, informative, and provocative paper.[2] We are all indebted to him for this historical sketch and summary of the present status of the art and science of mechanism. He has raised certain questions, has placed no blame, but has certainly made implications. Before examining who might be responsible for any neglect of the subject in this country, the writer must state that he believes the author is not fully acquainted with what is being taught in this country. He mentions a very limited treatment of velocities and incorrect treatment of accelerations. At Purdue University the time devoted to gearing and cams occupies a very small portion of the total subject matter. We use velocity diagrams, acceleration diagrams, and the application of Coriolis' law. There are other institutions which do the same. The writer is not aware of any incorrect applications in approved textbooks, which the author mentions. He is correct in that we teach analysis rather than synthesis.

Are the colleges to blame? The principle of education in the United States is education for everyone who can benefit and is not restricted as in Europe. Furthermore, in addition to giving a technical training, we attempt to develop character, leadership, business and social aptitude. As a consequence, our students do not have the opportunity to specialize during an undergraduate course, and we base our curricula upon what is desired by industry, employers, and taxpayers (or benefactors). They demand emphasis upon fundamentals without undue specialization. What should be eliminated from our crowded curricula to admit of new material and the necessary projective geometry?

Is industry to blame? Our industry demands a broad training in engineering and prefers to give specialized training which it needs. Industry still tends to minimize the highly theoretical method for the "cut-and-try." In justification of this attitude, we have the extraordinary success of empirical development. We have been so busy doing things that it would be well to survey and organize what we have done.

Perhaps the individual engineer is at fault in neglecting to follow the development of mechanism, its classifications and terminology. The need for such development has not been particularly evident, and engineers have entered pursuits of greater immediate necessity and opportunity. Furthermore, information on what has been done is not available. The publications in German, French, and Italian are not obtainable, and even the specialist cannot learn all that has been done. Those of us who are not specialists in "kinematics" can learn practically nothing. It was mentioned that the author is not entirely familiar with what is being presented in our colleges and to that the writer would add the thought that many of us are not sure as to just what he is talking about. Some of the things he has mentioned have long been familiar, but until we get a clear conception of what is involved, we are unable to pass judgment. The writer maintains that those who are familiar with these great developments should inform us of them. Therefore the author should be charged with the responsibility of presenting in the near future specific statement and example of application of the principles involved.

COMMENT BY COLIN CARMICHAEL[3]

Referring to the theories of kinematic synthesis the author states: "In the absence of knowledge of such a theory, the engineer once more is obliged to resort to a trial-and-error process. Yet, to his credit, it may be said that, by his ingenuity, or intuition, he frequently arrives at suitable solutions by such a process. Here also, something is obviously wrong!"

It is not obvious why this state of affairs should be considered wrong. There is scarcely a branch of mechanical design that does not depend to a large extent on trial-and-error procedures. For example, designing for strength usually involves proportioning from practical consideration and checking by stress analysis, which may involve several trials and modifications. Only in the simplest cases is it possible to proportion a part directly and come out with the correct answer the first time. In the usual method of designing mechanisms, too, a practical mechanism is devised, and its behavior is checked by velocity and acceleration analysis. Why should a procedure that is considered satisfactory in one branch of design be considered wrong in another?

Carrying the comparison a step further, it is often observed that parts proportioned purely from stress consideration are not always practical. Is there any reason why the mechanisms which a synthetic method of design yields should meet practical requirements better than an "invented" mechanism?

If the author would give an actual example of the new method, applied to a familiar case, it would help designers to understand what the advantages are in departing from present procedures. It is suggested that a quick-return mechanical-shaper mechanism, or an internal-combustion-engine valve gear, or simply a piston-shaft mechanism for an engine, might be used to illustrate the new methods.

In conclusion, it would seem that the author, who alone seems to be familiar with the superior design methods of a country with which we are at war, is under obligation to make his information at once available to our own designers in a specific form.

COMMENT BY FREDERICK FRANZ[4]

The author is to be complimented for writing a short history of the development of the science of "kinematics" and of appending a historical bibliography of many important references on the subject. This writer can thoroughly agree with the author that the creation of new machinery requires not only great ingenuity but a thorough knowledge of mechanical principles and devices; that much highly useful theoretical information is in a foreign language, and there-

[1] Professor of Machine Design, Purdue University, Lafayette, Ind. Mem. A.S.M.E.

[2] "What Is Wrong With 'Kinematics' and 'Mechanisms'?" by A. E. R. de Jonge, MECHANICAL ENGINEERING, April, 1942, pp. 273–278.

[3] Associate Editor, *Machine Design*, Cleveland, Ohio. Mem. A.S.M.E.

[4] Consulting Engineer, New Haven, Conn. Mem. A.S.M.E.

fore not generally accessible to the English-speaking engineer; that projective geometry is an important tool and that geometric procedures very frequently (but not always) are more appropriate than analytical procedures in solving kinematic problems.

However, the writer questions, on two premises, the statement that the real test of the value of the science lies in the creation of new mechanisms: (1) If new mechanisms can be created without the science, but it is useful in investigating their practicability and usefulness, it must nevertheless be considered to be a very valuable science; (2) the creation of new mechanisms is not the primary duty of the practicing engineer but rather that of the research kinematician. The latter premise hinges upon the fact that a machine (or mechanism) by classical definition may comprise the simple elementary unit, as for example, a quadric chain or a pair of gear wheels, or it may comprise any complex combination of elementary units. The practical designing engineer is concerned chiefly with the choice of adequate and appropriate combinations and aggregations of known units. Although he may, on rare occasions, create a new unit, this research phase of the problem is, in the writer's opinion, not his duty.

In the author's criticism of the trial-and-error process, more exact definitions must again be requested.

If by the trial-and-error process, it is intended to refer to the process of establishing the dimensions of elementary units, it should be admitted that it is general practice to solve such kinematical problems directly. Some designers lack the knowledge of a direct approach to the solution of some complicated linkages. However, in many such linkages, analytical solutions are nearly impossible owing to their mathematical complexity. Furthermore, exact solutions in practical design are rarely necessary in link work. The experienced and thoroughly trained designer appraises the problem from the standpoint of the accuracy desired, the time required to solve the problem by both methods, and the consequences of probable inaccuracies, and chooses the optimum and more expedient method, often discarding the direct and exact method owing to its time-consuming properties.

If the words "trial-and-error process" are intended to define the procedure followed by the designer in originating his aggregation and combination of elementary units and subsequently in checking and correcting them for adequacy and propriety, the writer fears that the creative process of designing whole machines will forever remain the peculiar characteristic of a small percentage of the population which uses the trial-and-error process.

A knowledge of the synthesis of mechanisms will not eliminate the use of the trial-and-error process of creating aggregations and combinations of elementary units for usefully functioning machines. Kempe has devised a system of linkages based on similar triangles, which, by increasing the number of cells in the linkage, may be extended to generate any desired plane curve to the nth degree. Unfortunately his method is not usable in practice, because (1) practical machines consist of more than one elementary point locus, (2) for even simple curves an intolerably large number of links and joints is required in the Kempe cells, and (3) mathematical accuracy is rarely required in the equation of the locus of motion o a machine element. When such accuracy is required, the path is usually made to be an arc or a straight line either of which is easily generated. Gear-tooth generators are no exception, for in them the primary elements are straight lines and circles.

The creation of a successful aggregation and combination of elementary units to produce a prescribed practical result will probably never consist merely of putting the specifications a, b, and c into a hopper, turning the crank, and finding the resulting design x, y, and z, on a delivery belt. The designing engineer's job may be considered to concern itself with the reverse solution of the equation $a + b + c \ldots + n \rightarrow x + y + z$ in which, for illustration only, let us say a is the size of the bag in question, b the number of bags to be filled per minute, and c is the characteristic of the filling material, and, on the other side of the equation, x is the kinematic unit, y is the strength or deflection of the unit under the acting forces, and z is the cost of producing the unit. By assuming a specific value of x, y, and z, he can predict with reasonable certainty the propriety or impropriety of producing exactly or nearly a, b, and c.

Obviously, the most successful designer has at his instant mental command the largest number of practical and well-classified x, y, and z elements. While mentally swooping through any group of them, he never, even for an instant, loses the mental picture of the a, b, and c specifications with which the x, y, and z's are matched, compared and checked for propriety as they whirl past in review. Furthermore, his knowledge of the characteristics of each x, y, and z element is so keen that, if the desired match is not indicated, he knows how to modify the subelements of the trial group to yield an exact or acceptably close match with the specifications. Obviously, also, machine design, mechanics, and other engineering considerations are inseparably united with kinematics in this trial-and-error process of creating or synthesizing the one kinematic chain to be finally chosen for any given job.

Finally, it is the writer's opinion that the author's charge of overspecialization in engineering educations would surely be justified if kinematics of the more advanced nature were required of all engineering students.

COMMENT BY P. R. HOOPES[5]

The writer's comments on this paper are being made from the point of view of an engineer with 30 years of professional experience in developing complicated high-speed automatic machinery, much of that time as an employer of technically educated designers. Our problems are extremely varied and involve the daily application of mechanisms to a wide variety of new and practical uses.

The writer is in agreement with most of the author's criticism of undergraduate instruction in kinematics. He is probably correct in believing that the fault is largely due to lack of industrial experience of the instructors and to the inferior textbooks available. Unfortunately, textbooks are of necessity a product of academic authors. The nonacademic engineer has neither the pedagogical knowledge nor economic incentive to undertake the writing of textbooks. To the extent that he finds time to contribute to the literature of kinematics, it is usually in the form of papers on specific problems, often of a mathematical character and of a detailed technical content wholly unsuited to undergraduate instruction. The academic textbook compiler, without wide practical experience of his own, is therefore forced to fall back upon the admittedly defective knowledge which he acquired as an undergraduate and to rehash the conventional books of his predecessors. With kinematics in the United States today usually occupying a place in the engineering-school curriculum on an intellectual par with mechanical drafting, it is hardly surprising that it should meet with severe and well-deserved criticism.

What can be done to correct this condition the writer will not attempt to suggest, other than to express the opinion that kinematics should be taught to the undergraduate as a fundamental engineering discipline, aimed at strengthening his ability to think constructively in terms

[5] Consulting Mechanical Engineer, Philadelphia, Pa. Mem. A.S.M.E.

of motions in three dimensions. Since comparatively few engineering graduates will ever be called upon to solve complex problems of machine motions, it would seem not unreasonable to limit detailed mathematical development of the subject to graduate courses.

With one aspect of this paper the writer is in fundamental disagreement. The author states: "To be a vital science, its principal aim must be . . . the creation of new mechanisms, or of mechanisms that fulfill given or desired conditions." And again: "It is mainly the creation of new mechanisms that form the real test for the value of this science." Except in an extremely limited and special sense, this science is, in the writer's opinion, totally incapable of producing any such results as are implied by these statements.

Kinematics as a tool for analyzing concrete mechanisms, and as a means of systematizing and classifying knowledge of mechanical motions, is of the utmost practical value to the machine designer. It enables him to avoid potentially unsatisfactory mechanisms and to select and perfect the satisfactory ones. In many respects, it bears much the same relation to the design of practical mechanisms that elastic theory does to structural design.

Ever since Reuleaux advanced claims for kinematic synthesis, it has been credited with being capable of producing new mechanisms to meet specified practical requirements. The writer is not familiar with a single instance in which it has done this. Reuleaux himself, in his most interesting and suggestive study of chambercrank trains, did nothing but construct a classified dictionary of mechanisms, long known in practice. If the modern exponents of kinematic synthesis have been more successful, the writer would like to be referred to the machines which they have created by this method.

A thorough knowledge of kinematic theory would, undoubtedly, be helpful to anyone assigned to solve the geometrical problem, let us say, of laying out a mechanism capable of generating a catenary curve, using only turning pairs in his linkwork. Perhaps a problem of this kind might be of interest to a mathematician. It is doubtful that it would be to a machine designer. If such a motion were required in a practical machine, it would be in association with many other conditions entirely extraneous to the geometry of the curve. Thus, the permissible weight of the parts, their size, strength, stiffness, method of driving, speed of operation, relationships of associated mechanisms, work to be performed, attainable manufacturing tolerances, allowable departure of the curve from exactness, maintenance of the mechanism in service, and initial cost are only a few of the factors which the designer would have to consider if his design were to be anything other than an exercise on the drawing board. Since there are any number of well-known methods for producing elementary motions, the designer's task is one of selection, combination, and co-ordination of known elements to meet the infinitely varied requirements of practice, rather than the conception of so-called new elements out of a kinematic vacuum.

By all means let us see the mechanisms which are said to result from kinematic synthesis, even if, as in one published case which the writer recalls, they involve 42 links to generate a simple curve having no known use in practice. But let us not mislead our undergraduates. Practical machinery does not originate in mathematical formulas nor in beautiful vector diagrams. A drafting machine is a useful tool. It is not a substitute for a draftsman.

COMMENT BY C. H. YOUNG[6]

Of particular interest in this paper is the very carefully developed outline of the historical background of this subject. Certainly, by this means, the author has presented a true case for more complete research toward developing advanced methods and techniques in the science of mechanisms. We will all await with interest the publication of his findings along these lines as promised in the paper.

However, the writer cannot agree with him in the manner in which he would introduce this more complete study into the college curriculum. To make clear the objections it would be best, first, to state briefly what the writer believes to be the accepted aims of an engineering education. From this definition the general pattern of course content can be outlined, and then an evaluation of this new presentation can be made to see exactly when and how it fits into the educational pattern.

Primarily, the purpose of an engineering education is to train young men so that they may take their places in the field of their profession and at the same time to so train them that they can assume the responsibilities imposed upon them by the community in which they live. To achieve this end the college must provide a course of study including broad humanities nicely balanced against techniques of some special engineering field.

The phrase "nicely balanced" is used advisedly, because of the type of questions industry is asking on the recommendation-for-employment blank. The personnel departments are stressing questions dealing with the character of the applicant and seldom ask anything about his academic preparation. As one interviewer said: "If the applicant is a graduate of a recognized engineering college it is a foregone conclusion that he has had sufficient elementary training in the fundamental technical courses for our purposes." What industry is interested in is the prospect of the applicant's developing beyond the mere technician.

To provide time in the curriculum for these broadening studies and yet not increase the total time has necessitated a rearrangement of schedule for technical subjects. To accomplish this satisfactorily would indicate setting up a definite end toward which the technical training should point.

Unfortunately too sharp a definition of this end cannot be attempted because the student cannot so early in his career exactly define his lifework. Even if it is relatively simple to decide whether he wants to be a mechanical, electrical, civil, or chemical engineer, he still has minor choices to make. And these will largely be influenced by the availability of openings, the locality in which he lives, and other factors which he cannot anticipate when he first enters college. Even after he has started on his lifework, developments in the particular job may eventually lead him far away from that particular branch of engineering in which he was first employed.

That this is so is indicated by a study of the roster of graduates of any college. A careful reading will show a large number of men who are engaged in fields widely divergent from the studies they pursued in college as indicated by their degree—electrical engineers doing machine-design work, civil engineers in industrial positions, and the like.

So the colleges are forced to keep their instruction on a plane general enough so that their students may enter the positions which are open to them upon graduation. For instance, the mechanical-engineering students must be so prepared that they can enter the power-plant field, the machine-design field, the industrial-engineering field, the automotive field, and others. To point all the instruction given at any one institution to only one of these fields would be disastrous. When these students are ready to enter the industrial field, industry might not at that particular moment be

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able to absorb them, but it could offer work in some other field, provided their training was sufficient to permit them to take the responsibilities of the minor positions open to inductees.

Consequently the ideal course would be one which trained the student sufficiently in fundamentals of engineering and in certain specific techniques so that he might be assured at least of induction into some position in a particular engineering field. After his first employment his progress would depend on his own development, and this would necessitate study of a more specialized nature.

The reader will probably now see where the writer would place this special course under discussion. In fact, the author himself intimates this in his conclusions, when he says: "However, when these obstacles are surmounted, this science will not only be one of the most fundamental engineering sciences, just as mathematics and general mechanics, but will become a universal science that should be studied by every engineer interested in mechanism and problems in which motion plays a part."

Rightly, the man interested in mechanisms and problems of motion, who consequently would most profit by research and advanced study of kinematics, would be the recent graduate who finds he is now definitely embarked on a lifework of machine design. At present he is doing routine drafting work in the design office and realizes that further study of a specialized character is necessary if his progress is to be assured. Since he is now engaged on work which requires exact analysis and synthesis of mechanisms, his future will depend on his further mastering of this science.

The writer therefore believes that the general courses in kinematics as now given, with due regard for development, are adequate for the average undergraduate, but most heartily agrees with the author that these courses are entirely inadequate for the specialist in designing new machines using intricate motions. However, the contention is that the proper time for introducing this study is when a student has attained the postgraduate level.

COMMENT BY PAUL GRODZINSKI[7]

The writer read the article "What Is Wrong With Kinematics and Mechanisms?" by A. E. Richard de Jonge with great interest and in general agrees with the opinion expressed.

In the discourse on the historical development of kinematics, he finds that too much emphasis is laid on German investigations in this field, and the valuable contributions of English scientists in this special branch such as Robert Willis, Kempe, Sylvester, Hart, and others have not been fully recognized. The writer is inclined to think that the work of Robert Willis on Principles of Mechanisms, published first in 1841, represents a work which in some respects is more revolutionary than the work of F. Reuleaux published about twenty-five years later. There is no doubt that numerous names and descriptions contained in Reuleaux's work were at least influenced by R. Willis; on the other hand Reuleaux seems to be the first who has found the kinematical relations between pairs, etc., but this is just that part of his investigations which has caused so many dissuasions.

[7] London, England.

AUTHOR'S CLOSURE

The paper was written for the purpose of instigating a widespread discussion on a subject of fundamental importance in the education of engineers. At the Annual Meeting of The American Society of Mechanical Engineers in December, 1941, at which it was presented, a lively discussion ensued. Not all the discussers of the paper at that meeting have presented their comments in writing nor did some present all their comments. These facts are particularly unfortunate, because, on the one hand, there was agreement as well as disagreement with the author's views, and on the other hand, it will not be possible to discuss here all the comments made. The written discussions, therefore, do not present a true picture of the opinions of other engineers, giving rather the side of those who were in disagreement either completely or in part. It is necessary to state this at the beginning to forestall the reader's forming a wrong and decidedly one-sided opinion.

The author desires to thank those who have taken the trouble of presenting their views in writing, even though their views may be contrary to his own. Only by airing all opinions can necessary progress result, and with this in mind the following remarks are made, which should be construed objectively, since nothing is further from the author's mind than to offend any one of the discussers, some of whom have been his personal friends for quite some time.

The written discussions comprise the comments of Messrs. E. S. Ault, Colin Carmichael, Frederick Franz, P. R. Hoopes, and C. H. Young. Of these Messrs. Ault, Carmichael, and Young are now or have been college professors, and it is only natural that they should rush to the defense of United States colleges and of the manner in which the subject under discussion is taught there. Messrs. Franz and Hoopes are consulting engineers and represent the viewpoint of the practical engineer rather than that of the theoretician or college professor. It is unfortunate that no comments for publication have been received from manufacturers of complicated machinery. Letters received privately by the author from such sources, which for various reasons are not for publication, however, show that practical engineers are conscious of the inadequacy of present-day methods, and that they would welcome any progress in the direction of more accurate and universally applicable methods.

Before dealing with the comments of the discussers, it is advisable to state again, and perhaps somewhat more precisely, the views of the author, who welcomes this opportunity to explain and elucidate the subject more fully.

To call the subject under discussion either "Kinematics" or "Mechanisms" is really a misnomer, and in choosing the title for the paper the author was fully conscious of the fact that he might confuse the issues rather than clarify them. However, these are the only terms with which English-speaking engineers are acquainted and, thus, by force of circumstances, the author had to use them in order to present the subject at all.

Strictly speaking, the subject under discussion is the science which deals with those devices used by man, which produce motion or take part in motion. "Motion devices" might express the subject more adequately, but is undesirable because it is a compound term. For the same reason the term "machinal devices," used by the author in his lectures, is not desirable either. "Movements," too, is unsuitable since it indicates usually complex devices rather than simple ones, for which it would also have to stand. The subject, really, is what the Germans call *Getriebelehre* (literally: science of drives), but the German term *Getriebe* means both that which drives and that which is driven, and a term ought to be found which expresses just that in the English language. To the author's knowledge, no such term exists. In addition, the term should be chosen so that an adjective may readily be formed of it. In lieu of a better term, let us, therefore, call this science the *Science of Machinal Devices*, since the term "mechanism" is reserved for something quite specific. Emphasis, however, should be laid on the fact that it is the *things themselves* that are of primary interest to the engineer and not the mathematical investigations of motion, which are incidental rather than fundamental, and thus are only of secondary

importance. The sciences which deal with the motions of machinal devices or their causes are therefore subordinate sciences. The science dealing with motion is known in the English-speaking countries as *kinematics*, that dealing with the equilibrium of the forces acting on or in a machinal device shall be termed *kinetostatics*, while that dealing with the motions produced by the external forces is known as *dynamics*. Since these latter three sciences are subordinate to the fundamental science of machinal devices, we get the grouping in Table 1.

TABLE 1

Machinal Devices, their elements and laws of composition, and their classification

Kinematics,	*Kinetostatics*,	*Dynamics*,
or the science of motions occurring in machinal devices	or the science of the equilibrium of the forces on and in machinal devices	or the science of motions that take place in machinal devices due to the external forces

Kinematics must be subdivided further into *kinematic analysis* and *kinematic synthesis*.

The author has purposely refrained in his paper from making any specific recommendations as to the stage of the engineering education at which these various sciences should be taken up. From the foregoing, it will have become clear, however, what part these various sciences must play in the training of young engineers.

Since throughout his career the engineer has to deal with machinal devices in one way or another, it is evident that every engineer should have a clear knowledge of the laws of their composition and should know how they may be classified so as to be available for future reference or use. The science of machinal devices is, therefore, a subject of fundamental importance, and the remark by the author that, when all "obstacles are surmounted, this science will not only be one of the most fundamental sciences, just as mathematics and general mechanics, but will become a universal science that should be studied by *every* engineer" (the subsequent words: "Interested in mechanisms and problems in which motion plays a part" would better have been omitted) is entirely correct. This science, which is more of a philosophical nature, teaches clear engineering thinking as does probably no other engineering science. Since it requires but little mathematics, it can be taught easily to undergraduates in the sophomore year. It gives the student a clear understanding of what types of members enter into machinal devices, what their functions are, what types of devices can be formed of them, what devices exist or could exist, how they are interrelated, how they should be classified, and, finally, how these devices can be applied in the various branches of engineering. Since the examples are taken from every branch of engineering, this science will widen his horizon, improve his reasoning power, and, generally, give him a facility in judging machinal devices and machines as to their proper use and value, that will astonish many a mature "specialist" engineer in that field. It will also provide a precise and more concise, that is, more economical, terminology and will show the student that numerous terms commonly used are poorly or wrongly coined as, for example, "prime movers." For, what generally are called prime movers, namely, the steam engine, steam turbine, waterwheel, water turbine, electric motor, etc. are not "prime" movers at all, because they simply convert an already existing (prime) motion into a (secondary) motion of a different type, that is to say, they are really "secondary movers;" however, this is by no means the entire story yet. In these cases, the prime movers are: The boiler in which steam is made to move, the intake and penstock in which water is given the required motion, the electric generator in which electricity is set in motion, etc. Such improper terms would then rapidly disappear.

Secondly, it is important for the student to learn how to attack a problem of plane motion, that is, he should learn how to use kinematic analysis, at least in the plane, both "mechanismally" and phoronomically. This branch of science, however, should be taught on a much broader basis than heretofore, making use, for this purpose, of the "quadratic transformation" in the plane, for by its aid the entire treatment of analysis by kinematic geometry becomes extraordinarily simplified and, in addition, perfectly general. Velocity and acceleration relations appear thereby in a new and different light which makes understanding much easier. Strictly speaking, projective geometry is required for the study of the quadratic transformation, but there exist two approaches which require very little knowledge of mathematics beyond Euclidean geometry and algebraic analysis for mastering this subject (for some problems, a knowledge of the rudiments of projective geometry is either helpful or necessary). Thus, it can be presented without difficulty to undergraduates, perhaps also in the sophomore, but certainly not later than in the junior year.

Thirdly, the theory of the equilibrium of forces on and in a machinal device in motion requires little more than the application of graphic statics. This branch of science could also be presented without difficulty to undergraduates, and probably would fit in best in the second semester of the junior year.

Dynamics of machinal devices and kinematic synthesis, on the other hand, require a somewhat riper mind and more mathematics and are, on that account, slightly more difficult to approach. For dynamics, a number of new concepts and projective geometry are necessary, and for kinematic synthesis, projective geometry and the theory of the higher algebraic curves (third to eighth order). Where these studies would fit in best is debatable, but the author believes, from his knowledge of those colleges with whom he has discussed the subject as well as from the opinions expressed by the different discussers, that it will be necessary to leave these more "specialized" branches of this science to the nebulous future called postgraduate courses, since there exists apparently an unwillingness on the part of the colleges to set aside time in the undergraduate curricula (senior year) for such more advanced studies.

It should here be stated, however, that a great deal can be accomplished by proper co-ordination of the mathematics, mechanics, and "kinematics" departments of the colleges by mapping out suitable course revisions which would take care of the requirements of the "kinematic" branch. At present, much time is wasted with unprofitable mathematical and mechanical problems which find no practical application anywhere, and they could easily be replaced by a treatment of the higher algebraic curves in mathematics and by certain inertia and reduction problems in mechanics, thus preparing the ground for advanced studies in machinal devices.

Having thus outlined in greater detail the relationship between the respective branches of this science and the stages at which these branches might best be acquired, it is now easy to deal with the criticisms advanced by the various discussers.

Professor Ault accuses the author of not being fully acquainted with what is being taught in this country. Professor Ault labors under a serious misapprehension, however, for the author has yet to see, or hear of, a course on "machinal devices," given in this country,

which presents the laws of their constitution. their classification, a clear and general kinematic analysis by means of the quadratic transformation, and a modern presentation of both kinematic synthesis and graphical dynamics. Such courses are not available in this country, Professor Ault notwithstanding. As an important item (although but one of many), Professor Ault cites the law of Coriolis as being dealt with in some United States colleges, but many of the available textbooks do not even mention it, much less give clear examples of its application. Others give an extremely poor derivation for it, which can only help to confuse the subject in the student's mind. At any rate, there is no textbook in the English language, known to the author, which clears up the entire subject of accelerations.

Next, Professor Ault attempts to whitewash the colleges, industry, and the individual engineer. He does this by suggesting that the courses advocated by the author are highly specialized courses. Thereby he reveals that he does not understand the entire subject, for, as outlined in the foregoing, the majority of these courses are fundamental, both in the knowledge they impart and in the methods they use. The entire reference to American university training and its difference from European training is out of place, as this did not form part of the author's paper. Professor Ault is wrong, however, when he condemns European education as being "restricted." It is open to anyone who can pay for its tuition, just as is the case here. How similar some European and American educational systems are may best be illustrated by referring to a comprehensive discussion "On Engineering Education," by Professor Inglis, in England, in his address on the occasion of his election as president of The Institution of Civil Engineers.[8] What Professor Inglis has said holds true almost word for word also for technical education here in the United States.

Professor Ault's statement that American "curricula are based upon what is desired by industry, employers, and taxpayers (or benefactors)" who demand emphasis on fundamentals without undue specialization is correct to some extent, but, as stated before, he does not realize the fundamental nature of the courses outlined by the author. He asks: "What should be eliminated from our crowded curricula . . ." The answer is simple indeed: All the antiquated irrelevant matter which is unnecessary and confuses the subject and degrades it almost to drafting, and instead inclusion of the modern methods. He further makes the statement that "industry still tends to minimize the highly theoretical method for 'the cut and try.'" Thereby he shows that he is not well acquainted with the desires of industry, for, in most of its branches, highly theoretical methods are being made use of every day.[9] These the young engineer has to acquire when he enters industry, and industry has to pay for this tuition which really should be given in the colleges. It is a well-known fact that college instruction always lags behind the requirements of industry, a truly unhealthy state of affairs. The question how far it lags behind is, however, one which touches upon the economic status of the country as a whole.

Professor Ault says further: "We have been so busy doing things that it would be well to survey and organize what we have done." It is true that, in the past, plenty of money was available for "experimental" or "development" purposes, but it is equally true that this will not be so in the future, and it is to the future that the author is looking in advocating the study of the fundamental courses outlined.

Just as industry, in the past, has not bothered itself too much about progress elsewhere, but rather relied on experiment even though it was frequently merely a duplication of effort, so also has the individual engineer not bothered himself about this science further than what was immediately available. Professor Ault tries his whitewash of the individual engineer or teacher by stating that the publications on this science are in German, French, and Italian and are not obtainable, and even the specialist cannot learn all that has been done. It is true that not *all* the information from German sources is available publicly,[10] but enough is available in the libraries of the United States to give the serious investigator a clear picture of what progress has been made in this science in the countries mentioned. The fault does not lie in the unavailability of the literature, but in the unwillingness of instructors and engineers to study it, and this is clearly the fault of the individual. Thus, when Professor Ault states "that many of us are not sure as to just what he (the author) is talking about," he may be perfectly honest, but the fault of this ignorance clearly lies with the individuals. In his final statement, Professor Ault, in common with the other discussers, shifts the blame to the author and charges him with the duty to make the modern methods available in the English language. This is a large order, too large for any one man, and it cannot be done piecemeal fashion. It will have to be reserved for a comprehensive treatise of the subject, which requires time and an almost superhuman effort.

Mr. Carmichael, who previous to being associate editor of *Machine Design* was assistant professor of mechanical engineering at Rutgers University, advances indeed a strange thesis when he asks why the trial-and-error process should be considered wrong in kinematics although there is scarcely a branch of mechanical design that does not depend on such procedures. As an example, he cites designing for strength, and asks: "Why should a procedure that is considered satisfactory in one branch be considered wrong in another? The answer is simple. It is *not* satisfactory in the designing for strength, but we do not have, at present, any better method while we have better methods in kinematics. Two wrongs don't make a right! What he advocates is just inspired by human inertia, old custom, or unwillingness to change (sometimes hidden under the term "conservatism").

His reasoning is wrong again when he states: "It is often observed that parts proportioned purely from stress considerations are not always practical. Is there any reason why the mechanism which a synthetic method of design yields should meet practical requirements better than an 'invented' mechanism?" Yes, there are reasons, for, as just stated, the two branches cannot be compared in the first instance, and in the second instance, the "invented" mechanism—the result of a trial-and-error process—in many cases is only one of those possible and may not always be the most suitable one, while the geometrical approach usually gives all the solutions possible, from which the best or most suitable one can be selected. Thus, what holds for one branch need not hold for another, and in designing for strength, such methods do not exist. Incidentally, "invention is the end of searching" which is made easy if one knows how to, that is, by the use of geometrical methods in this case.

Since the author carefully refrained from giving in his paper any opinion as to the method of introducing the study

[8] Journal of the Institute of Civil Engineers (London), Nov., 1941, pp. 1–18.

[9] See, for example, the investigation by by M. E. Martellotti, of the Cincinnati Milling Machine Company, "An Analysis of the Milling Process," Trans. A.S.M.E., vol. 63, 1941, pp. 677–695, and this author's comments on it, *ibid.*, pp. 698–699.

[10] The author has been fortunate in having been able to acquire a fairly comprehensive library of those French, German, and Italian books on this subject, which are not available in American libraries.

of this science into the college curriculum, it is difficult to see how Professor Young can state that he "cannot agree with him in the manner in which he would introduce this more complete study into the college curriculum." Professor Young makes the same mistake as Professor Ault by simply assuming that the studies advocated by the author form *highly specialized courses*. By suggesting that they are, he builds up a straw man for the purpose of knocking him down by stating that these highly specialized courses should be given as postgraduate courses. In doing so, he gives a brief dissertation on engineering education. The author has already referred to the far more comprehensive discussion on this subject by Professor Inglis. Little need, therefore, be said here, except that Professor Young, like Professor Ault, does not realize the fundamental nature of these studies, which is not surprising as he too, apparently is not acquainted with the modern development. Consequently, his final statement "that he believes the general courses is kinematics *as given now*, with due regard for development, are adequate for the average undergraduate," must be rejected emphatically, and all that has been said with respect to Professor Ault's discussion hold equally true for that of Professor Young, particularly that present-day courses can easily be modified, and should be so, to include the general viewpoints introduced by the modern development. It is the same old story of unwillingness of college men to change existing courses and methods in teaching them.

Mr. Franz, as a practical engineer, although agreeing with some of the author's statements, disagrees with him on the value of this science (kinematic synthesis) which he does not believe to lie in the creation of new mechanisms or mechanisms to suit given conditions, but rather in the investigation of new mechanisms found by "invention." Furthermore, he advances an argument by stating that the creation of new mechanisms is not the province of the practicing engineer. Regarding the first part, certainly, a science which makes possible the investigation of existing mechanisms is valuable to the practicing engineer. Why, however, the latter should be placed on a lower plane than the theoretical engineer, in the second part of his statement, is not clear at all. There is no valid reason why the practicing engineer should not strive to create new mechanisms or known ones of better form or proportions, if he can improve thereby the machines he designs. With regard to entire machines, Mr. Franz, obviously, has not read the author's paper very carefully, for at no place has the author claimed that entire machines can be designed by Mr. Franz's "Hopper Method." All the author has claimed is that suitable mechanisms, which will satisfy given conditions, can now be designed on the drawing board by geometrical methods. By diverting the discussion to complete machines, Mr. Franz also is guilty of building up a straw man for the purpose of knocking him down by the statement that the conditions for designing complete machines by mathematical methods are much too complicated, and that, for this reason, such design is not feasible. It may be stated here that, although we are still a long way from this goal, yet, a good deal can already be accomplished by mathematical methods in the field of design of complete machines or devices that will perform a desired function. Professor Franke demonstrated this some twenty-odd years ago by using for this purpose the theory of combinations. Apparently Mr. Franz did not know of this method, otherwise he would, surely, have modified his statement accordingly.

One further point should be rectified. The author has referred to Kempe's work simply to show that by Kempe's method it is possible to obtain mechanisms which will describe accurately algebraic curves of any order. This may involve many links and joints. However, most of the curves used in practice are of the eighth order, or lower, and these can be obtained as coupler curves, etc., with the use of only a few links. This is the principle on which modern kinematic synthesis operates to a large extent. It is, therefore, not necessary to use a ridiculously large number of links and joints as has been intimated by Mr. Franz and also by the last discusser, Mr. Hoopes.

It is, indeed, gratifying to the author that, at least, one of the discussers, Mr. Hoopes, also a practicing engineer, agrees with him on the major part of his criticism of poor undergraduate instruction in American colleges, which, he states, "is largely due to lack of industrial experience of the instructors, and to the inferior textbooks available," which are merely a "rehash of the conventional books of his (the instructor's) predecessors." In stating "with kinematics in the United States today usually occupying a place in the engineering-school curriculum on an intellectual par with mechanical drafting, it is hardly surprising that it should meet with severe and well-deserved criticism," Mr. Hoopes is far more outspoken than the author. It would be well if the college authorities would ponder a good deal about this "damning" statement which comes from a practical engineer. In Mr. Hoopes' opinion "kinematics should be taught to the undergraduate as a *fundamental engineering discipline*, aimed at strengthening his ability to think constructively in terms of motion in three dimensions." The detailed mathematical development of the subject, he would leave to postgraduate courses. Thus Mr. Hoopes agrees with the author on almost all counts.

Only with one aspect of the paper, Mr. Hoopes is in "fundamental disagreement." Although he acknowledges the value of kinematic analysis and classification of "mechanical motions" as being "of the utmost practical value to the machine designer," Mr. Hoopes expresses disbelief in the claims made for kinematic synthesis that it permits the construction of mechanisms to suit given conditions. He says that, in his opinion, "this science is totally incapable of producing any such results." He says further, "Ever since Reuleaux advanced claims for kinematic synthesis, it has been credited with being capable of producing new mechanisms to meet specified practical requirements. The writer is not familiar with a single instance in which this has been done." It was wise of him to state that *he* is not familiar with such results, but that does not prove that they have not been achieved. It is unfortunate that Mr. Hoopes seems to be familiar only with antiquated American textbooks. In the modern German textbooks he will find many examples of mechanisms which have been developed for particular requirements by purely "mechanismal" methods or by geometrical methods of reasoning. To name only a few mechanisms thus derived: W. Hartmann's steam-engine valve gear,[11] in which the usual valve spring for closing the valve has been eliminated by a completely constrained mechanism; R. Hundhausen's step-feed gear for punching the notches into generator rotor disks;[12] H. Blaise's investigations for obtaining, among others, mechanisms which have several periods of rest at given points of a cycle;[13] Lichtenheldt's design of the mechanism for throwing the shuttle in a mechanical loom drive;[14] R. Franke's discovery, by kinematic synthesis, of three hitherto unknown types of electric motors which, while not practical, are

[11] Jahrbuch der Schiffbautechnischen Gesellschaft, vol. 6, 1905, p. 228–255.

[12] *Elektrotechnische Zeitschrift*, vol. 23, no. 51, Dec. 18, 1902, pp. 1095–1098, and no. 52, Dec. 25, 1902, pp. 1130–1133.

[13] V.D.I. *Zeitschrift*, vol. 75, 1931, Sept. 26, pp. 1223–1227, and Oct. 17, pp. 1303–1309.

[14] *Maschinenbau* der Betrieb, vol. 15, 1936, pp. 405–407.

feasible and for that reason exceedingly interesting;[15] and many others. The entire procedure is commonplace today in Germany, and German machine-design periodicals are full of examples of this kind.

Mr. Hoopes' remark with regard to Reuleaux's study of chamber trains requires some modification, for, by his systematic analysis, Reuleaux has actually found a number of new chamber trains, which he is modest enough to give as "examples" only. Nevertheless, they were not known previously.

Mr. Hoopes' example of the design of a catenary curve by means of a mechanism shows to what length people will go to defend their contention. Naturally, it cannot be taken seriously. With regard to the design of machines, Mr. Hoopes is correct in stating that the designer's task is one of selection, combination, and coordination of known elements rather than the conception of new elements—out of a kinematic vacuum (whatever that may be). The discusser's reference to a mechanism involving 42 links to generate a simple curve verges on the ridiculous. In practice, such a curve can probably be produced with sufficient accuracy by six or at most eight links as mentioned previously.

Before summing up, the question of making the foreign literature on this subject available to American engineers must be taken up again. Obviously, it is highly unfair in charging the author with the impossible task of translating the relevant foreign literature, as was done at the meeting. He has translated a few books, however, among which is the well-known monograph by Signor Lorenzo Allievi, entitled "Cinematica della Biella Piana." This famous work deals with the quadratic transformation in a manner understandable to American engineers who are trained very one-sidedly, i.e., analytically. Signor Allievi was greatly interested in this translation, and not only presented the author with a copy of his book and encouraged him in many ways, but actually was willing to have the translation (500 copies) printed in Italy at his own expense, provided The American Society of Mechanical Engineers could raise the necessary funds to pay for stenographic and typographical help, import duty, and the charges for handling and distribution. In spite of the author's great efforts, it was found impossible, however, to raise the funds, and the valuable opportunity of making this book available to American engineers has, most regrettably, been lost forever, for Signor Allievi recently passed away without seeing his greatest wish fulfilled of having his work translated into English.

And now a few concluding remarks. All discussers have shown that they are not acquainted with recent developments in this science of machinal devices. The colleges have been blamed not only by the author, but also by a practicing engineer of repute about their backwardness. Since the blame has been laid squarely at their door, it is up to them to take steps to remedy this state of affairs by raising the level of instruction from a par with drafting to scientific instruction for the benefit of the students. The most important factor, however, is the student body itself. It is up to the students, to *demand* better instruction in this science and to see to it that they get it. If this demand is emphasized strongly enough, the colleges, who primarily have to cater to the wishes of the students, will have to fall in line and will have to provide instructors competent to give such improved instruction. If the students, and industry which, in the end, has the greatest interest in better instruction, will let this opportunity pass without doing anything about it, all will remain as it is, and the attempt of the author to draw attention to a very neglected field of science will have been wasted completely.

After the author's closure had been set in type, a further comment has been received, this time from England. Mr. Paul Grodzinski the writer of this comment states that, in general, he agrees with the author, but that, in his opinion, too much emphasis has been laid on German investigations in this field and that the valuable contributions of English scientists in this special branch such as Willis, Kempe, Sylvester, Hart, and others have not been fully recognized.

First, to put Mr. Grodzinski straight, the author has given British mathematicians credit although not mentioning all of them by name. If Mr. Grodzinski had read the paper carefully, he would have found, on page 276, particularly mentioned S. Roberts, J. J. Sylvester, W. K. Clifford, W. Burnside, A. Cayley, Th. Preston, and also A. B. Kempe. It is true that Robert Willis was not specially mentioned nor was H. Hart. The author differs from Mr. Grodzinski's opinion about the value of Willis' book which, while containing much useful material, also contains much that is wrong. Thus, Mr. Grodzinski will see that the author has "not" omitted reference to the work of his former compatriots. That Mr. Grodzinski belittles Reuleaux's work and praises the work of Willis instead would seem to indicate a sudden change of heart, for Mr. Grodzinski, who is not a newcomer in the field of kinematics, was well known as a patent attorney who practiced for many years in Berlin, Germany.

A. E. R. DE JONGE.[16]

[15] See the author's paper, reference 19, pp. 32–33.

Only examples have here been mentioned, the literature for which is available in United States libraries.

[16] Adjunct Professor, Polytechnic Institute of Brooklyn, Brooklyn, N. Y. Mem. A.S.M.E.

REVIEWS OF BOOKS

And Notes on Books Received in the Engineering Societies Library

Production Control

PRODUCTION CONTROL. By Lawrence L. Bethel, Walter L. Tann, Franklin S. Atwater, and Edward E. Rung. McGraw-Hill Book Co., Inc., New York, N. Y., 1942. Cloth, 6 × 9 in., 276 pp., 92 figs., $2.75; teachers' manual, $0.10.

REVIEWED BY JOSEPH M. JURAN[1]

THIS book is stated by the authors to have been written "primarily for the use of classes in production control organized under the Engineering, Science, and Management Defense Training Program". The material on which the text is based was a survey of some sixty representative manufacturing companies in Connecticut, supplemented with individual and group conferences with representatives of a broader list of companies.

The following specific criticisms can be offered:

1 With emphasis on Defense Training it would seem hardly in point to dwell at length on the statistical problem of long-range sales forecasts and on the associated problems in economics.

2 The text material is almost exclusively on the basis of organization by

[1] Assistant Administrator, Office of Lend Lease Administration, Washington, D. C. Member A.S.M.E. Management Executive Committee.

functional departments. The modicum of discussion on product type organization is hardly enough to be judged an adequate coverage.

3 The chapters on Procurement and on Quality Control appear to reflect an oblique, rather than a direct, experience. This is particularly true in the discussions of "When to inspect," "Where to inspect," and "How much to inspect." Here the authors merely leap from crag to crag without any explanation of the intervening valleys of modern quality-control technique.

4 In the chapters on Routing, Scheduling, and Dispatching, the authors have painted with a surer hand. The text here evidences a firm familiarity with the problem, and the liberal use of well-chosen forms and examples rounds out these chapters well.

5 The Bibliography and references are limited in breadth, three fourths of the references being to five well-known standard texts.

It would be supposed that from the survey made by the authors, there could be developed, for their stated purpose, a realistic and readily digestible text on Production Control. Unhappily, the authors have fallen distinctly short of this. They have, instead, except in several of the chapters, produced a rather broad and vague series of statements, saturated with well-worn platitudes. On most subjects the statements of what is good practice and what is bad practice are so far apart as to leave without answer the bulk of the cases which can arise.

It cannot be concluded that this book will become a formidable rival to the other texts in the field.

Books Received in Library

AIRCRAFT ENGINE DESIGN. By J. Liston. McGraw-Hill Book Co., Inc., New York, N. Y., and London, England, 1942. Cloth, $6 \times 9^1/_2$ in., 486 pp., illus., diagrams, charts, tables, $4.50. The component parts of an aircraft engine are described and discussed in detail, with emphasis upon fundamentals of mathematics, mechanics, and machine design necessary for successful designing. Suggested design procedures, problems, and references to further reading accompany each chapter. A large section of useful engineering data, including brief specifications of American marine, vehicle, and aircraft engines is appended.

AIRCRAFT INSPECTION. By E. E. Wissman. McGraw-Hill Book Co., Inc. (Whittlesey House), New York, N. Y., and London, England, 1942. Cloth, $6 \times 9^1/_2$ in., 268 pp., illus., diagrams, tables, $3. In this volume an experienced inspector presents practical information on the factory inspection of aircraft. Every step, from fabrication and subassembly to preflight and delivery inspection, is covered in detail, with full information.

AIR RAID PRECAUTIONS HANDBOOK NO. 14. (First edition.) The FIRE GUARDS HANDBOOK. Great Britain, Ministry of Home Security and Scottish Home Department. Published by His Majesty's Stationery Office, London, England, 1942. Paper, $4 \times 6^1/_2$ in., 45 pp., diagrams. Obtainable from British Library of Information, New York, N. Y., $0.05. The specific duties of a fire guard in connection with air raids are outlined. Approved methods for dealing with incendiary bombs and fires are described, and consideration given to the organization of fire guards for most efficient action.

ALLOY CONSTRUCTIONAL STEELS. By H. J. French and F. L. Laque. American Society for Metals, Cleveland, Ohio, 1942. Cloth, $6 \times 9^1/_2$ in., 294 pp., illus., charts, tables, $4. Based on a series of lectures, this discussion of the utilization of alloys in constructional steels illustrates the importance of the alloy steels and is also intended to provide help in the selection of steels for different classes of service. Following a general survey of the subject of alloy steels, both unhardened and heat-treated, the author covers service at subatmospheric and elevated temperatures, wear, corrosion, and special treatments. The methods of identification of S.A.E. and A.I.S.I. steels are explained.

AUDELS MECHANICAL DICTIONARY for Technical Trades, Arts, and Sciences. By N. Hawkins and E. P. Anderson. Theo Audel and Company, New York, N. Y., 1942. Fabrikoid, $5^1/_2 \times 8$ in., 948 pp., $4. This dictionary published about thirty years ago is reissued with a supplement nearly one half as large as the original work. It contains about seventeen thousand technical words and terms.

DRILL PRESS, Job Training Units. 103 pp. SHAPER AND PLANER, Job Training Units. (Dunwoody Series, Machine Shop Training Jobs.) American Technical Society, Chicago, Ill., 1942. Paper, $8^1/_2 \times 11$ in., 115 pp., illus., diagrams, charts, tables, $1.25 each. As in previous volumes of this set of manuals for machine-tool training, the material consists of instruction sheets for jobs covering the setting up and operation of various types of machines as in actual practice. The jobs are progressively more difficult, and each is accompanied by a check sheet containing questions to be answered by the learner.

ELECTRIC MOTORS IN INDUSTRY. By D. R. Shoults and C. J. Rife, edited by T. C. Johnson. John Wiley & Sons, Inc., New York, N. Y., Chapman & Hall, London, England, 1942. Cloth, $6 \times 9^1/_2$ in., 389 pp., illus., diagrams, charts, tables, $4. Written for the industrial engineer, this book presents information on the characteristics and control of electric motors which will aid in the efficient selection and installation of the proper equipment for typical jobs. Enough description of the mechanical construction of motors is given to aid in understanding their operation. Two chapters deal with the principles and applications of electronic devices, but no attempt has been made to cover the generation, transmission, or distribution of power.

EMPLOYMENT TESTS IN INDUSTRY AND BUSINESS, a Selected, Annotated Bibliography. (Bibliographical Series No. 67.) Prepared by H. C. Benjamin. Princeton University, Industrial Relations Section, Princeton, N. J., 1942. Paper, 6×9 in., 32 pp. $0.25. To aid war industries and agencies in canvassing the possibilities of employment tests this selected, annotated bibliography of the best available literature in the field has been compiled. The two largest sections cover specific types of tests and reports of company experience and of research in the use of tests.

ENGINEERING DRAWING AND MECHANISM. (Rochester Technical Series.) By H. J. Brodie. Harper & Brothers, New York, N. Y., and London, England, 1942. Cloth, 9×11 in., 241 pp., diagrams, charts, tables, $2.25. This textbook is one of a series developed as part of a program for developing practical teaching materials which will be closely related to the actual requirements of various jobs in industry. The two sections of this book provide a sound foundation in the general phases of mechanical drawing and in the drafting of cams, gears, and mechanisms.

Fairhurst Manual of HIGH EXPLOSIVES, INCENDIARIES, and POISON GASES, for Home Defense Workers and Wardens. By I. Fairhurst. Fairhurst Book Co., Greenfield, Mass., 1942. Paper, $5 \times 7^1/_2$ in., 110 pp., tables, $1. This pamphlet is intended for wardens and laymen interested in civilian defense, for whom it provides a simple, understandable description of various explosives, incendiaries, and poison gases, with instructions as to methods of protection.

FIRE PROTECTION IN REFINERIES. Third edition, 1941. American Petroleum Institute, Division of Refining, New York, N. Y. Paper, $8 \times 10^1/_2$ in., 116 pp., illus., diagrams, charts, tables, $1. A comprehensive review is presented of the principles underlying adequate measures for fire prevention, control, and extinguishment, with the emphasis on prevention. An appendix contains detailed information and tabular data illustrative of the manner in which these principles have been applied in some typical refineries.

FIRST CENTURY AND A QUARTER OF AMERICAN COAL INDUSTRY. By H. N. Eavensen. (Privately printed, Koppers Building, Pittsburgh, Pa., composed and printed at the Waverly Press, Baltimore, Md.), 1942. Cloth, $7 \times 10^1/_2$ in., 701 pp., tables, charts, maps, $8. Compiled mainly from original documents, this comprehensive history of the American coal industry presents an authentic picture of its development. The bulk of the material is arranged by states, with a brief section on the very early history and a general summary. Direct quotations from many sources and reproductions of original maps preserve the feeling of the early periods. One hundred and sixty pages are devoted to an extensive compilation of production statistics, and there is a large bibliography.

FLUORESCENT LIGHTING MANUAL. By C. L. Amick. McGraw-Hill Book Co., Inc., New York, N. Y., and London, England, 1942. Cloth, $6 \times 9^1/_2$ in., 312 pp., illus., diagrams, charts, tables, $3. This practical manual gives authoritative information on the construction and performance of all types of fluorescent lamps, covers principles and methods of calculating illuminating requirements and designing luminaries, and furnishes methods and special pointers for installation and maintenance. Working data are given and a comparison of the economic factors of fluorescent and incandescent lighting is included.

FOUNDRY SAND CONTROL. By H. W. Dietert. Great Lakes Foundry Sand Co., Detroit, Mich., 1941. Cardboard, 9×11 in., 54 pp., illus., charts, tables, $4. This book is designed to provide the detailed information on core and molding sands which every foundry needs, and to act as a reliable guide to the precautions needed to prevent defects in castings, and to the methods of discovering their causes and applying corrections when defects occur. Complex relationships have been simplified by charts, graphs, and formulas to facilitate finding and applying the information given.

A.S.M.E. NEWS

And Notes on Other Engineering Activities

The A.S.M.E. 1942 Annual Meeting Program Calls for 5 Full Days, November 30–December 4

"IT'S an engineers' war!" Over and over again is this fact being brought home to the A.S.M.E. Meetings and Program Committee who has found it imperative to extend the 1942 Annual Meeting of the Society in New York City to five days, Nov. 30 to Dec. 4, to present the wealth of available papers vital to the war effort of production for victory.

Headquarters will be at the Hotel Astor and thus all sessions will be kept within easy reach of everyone. Great care is also being taken so to schedule events as to make it necessary for the minimum number of members to remain the entire five days of the meeting. Actually the meeting will run over a period of a week as certain committees are planning to meet on Saturday, Nov. 28, as well as on Sunday when the Council and Local Sections delegates hold sessions also.

Important Luncheon Session on Monday

An innovation of importance at this year's Annual Meeting is the luncheon to be staged on Monday by the Committee on Education and Training for the Industries to give an opportunity to all members to gather in one meeting to hear talks by leaders in personnel and management fields on the importance of ingenuity in American industry. It is the purpose of the Committee to present a galaxy of prominent speakers to lead the discussion on this subject. Heading the list will be Igor I. Sikorsky whose accomplishments have stamped him as a successful exponent in the use of ingenuity. He will illustrate his subject of "Creative Engineering, Inventiveness and Intuition" by a most unusual film of the helicopter. Following Mr. Sikorsky the speakers, so far known, include A. R. Cullimore, president of the Newark College of Engineering, K. K. Paluev of the General Electric Company, and Lawrence Langer, secretary of the Inventors' Council.

Be Sure to Read This

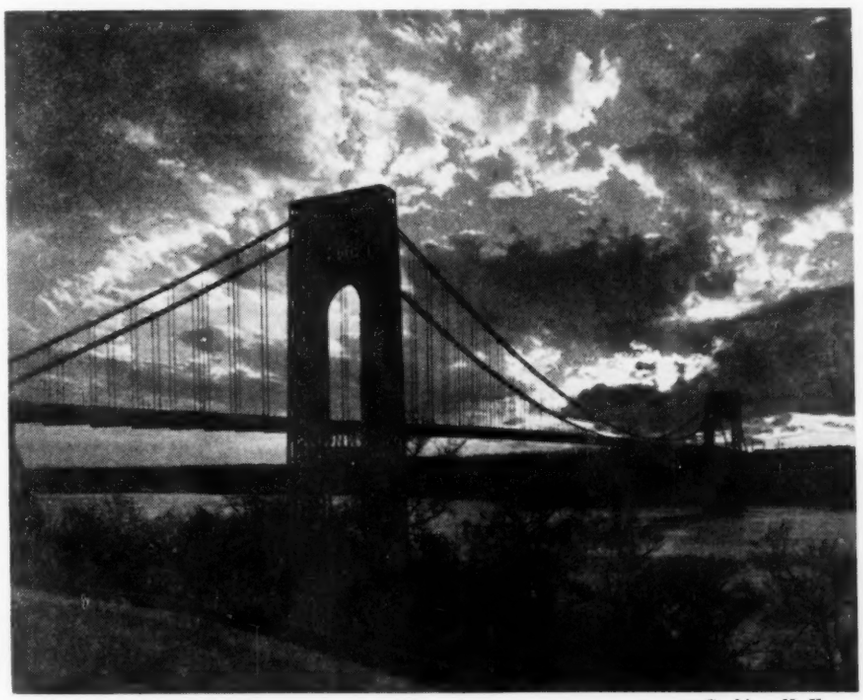
At this point it is well to emphasize the difficulties of managing a luncheon at the outset of any national meeting—immediately the question arises: Why do it? It is the only time at which no other luncheon meeting is being held and the Committee on Meetings and Program considers this session of such vital importance that they want to make it possible for everyone to attend. To this end, it is essential that they have the co-operation of the members in purchasing their tickets in advance as there will be no sale of tickets at the door for this particular luncheon. The reasons are many—it is the first day of the meeting and it will be impossible to give the hotel an estimate of the number to be expected if tickets are sold on the same day. There must be enough for all but none wasted. The room must be of adequate size and the service undelayed so that afternoon sessions may start promptly. Consequently, with the announcement of the Annual Meeting to be sent to all members, there will be enclosed a form for a reservation for this luncheon. *If you do not return this reservation by the date it will state*, you will not be able to attend this event—and we emphasize again—no tickets will be sold at the door. So send your reservation in on the proper blank which will be sent to you and make sure that you are able to attend what may well be one of the most important sessions of the whole meeting.

Business Meeting

The Executive Committee of the Council is calling the Business Meeting of the Society for four o'clock with the dual purpose of permitting members to attend the luncheon session just mentioned and with the hope that more members may be able to get away from their desks in time to attend this important session. The Business Meeting will be so arranged that it can continue for whatever period may be necessary to cover thoroughly any points which members may wish to discuss. However, the average duration of a Business Meeting is not over an hour and a half.

The Technical Sessions

At the present time arrangements are being made for forty-nine sessions; this is an increase of six sessions over the 1941 program. This will mean that, in addition to running sessions on Monday afternoon and Friday morning and afternoon, there will also be technical sessions on Monday, Tuesday, and Thursday evenings. Twenty-one different program-making agencies are concerned with planning the technical program and in addi-



Cushing, N. Y.

GEORGE WASHINGTON MEMORIAL BRIDGE ACROSS THE HUDSON RIVER FROM MANHATTAN TO THE PALISADES IN NEW JERSEY

Official Notice

A.S.M.E. Business Meeting

THE Annual Business Meeting of the members of The American Society of Mechanical Engineers will be held Monday afternoon, November 30, 1942, at 4:00 p.m. at the Hotel Astor, New York, N. Y., as a part of the Annual Meeting of the Society.

(*Signed*) C. E. DAVIES

Secretary

tion there will be arrangements under the direction of a dozen other committees involving such details as a special program for women attending the meeting, the photographic exhibit, and an unusually large number of technical administrative committee meetings, etc. The technical program of the Meeting will be published, as is customary, in the November issue of MECHANICAL ENGINEERING.

The Banquet

The banquet of 1941 was the largest in attendance ever held by the Society in New York and the Committee on Meetings and Program has practically completed arrangements with a speaker of such prominence that there is little question that the attendance will at least equal the 1200 who attended last year's banquet. Because of the fact that prominent men in government service have so many obligations to face it is not wise to indicate at this time who will be the banquet speaker even though this is well determined. Those who will receive honors have not as yet been decided upon but the group of prominent persons under consideration is such as to indicate that whoever is selected for these honors will find a host of friends among the members in attendance.

"All-Out" War Program for Photographic and Graphic Arts Exhibit to Be Held During A.S.M.E. 1942 Annual Meeting

THE photographic division of the Metropolitan Section of The American Society of Mechanical Engineers invites members and their friends to participate in the Seventh Annual Photographic and Graphic Arts Exhibit to be held at the Hotel Astor, New York, N. Y., in conjunction with the Annual Meeting of the Society November 30 to December 4, 1942. The program for the seventh annual salon has been changed to an "all-out" war program in keeping with the times, and the separate classes for nonmembers have been eliminated in the interest of conservation and economy.

The photographic entries will be judged in seven classes, the winner of each class receiving a silver medal, and three entries will be selected as the three best in the salon. These will each receive a gold medal. The Graphic Arts entries will be judged in one class and two gold medals will be awarded the two best entries.

The Seven Photographic Classes

The Seven Photographic Classes are as follows:

(1) ***Scrap Salvage and Material Conservation***

This class includes all pictures having to do with saving and collection of scrap materials and their utilization and also methods for the conservation of materials and the use of substitutes.

(2) ***Members of the Armed Forces***

This class includes all pictures of soldiers, sailors, and marines, whether on duty or on leave.

(3) ***Civilian Defense Activities***

This class includes air-raid precautions, Red Cross work, canteen activities, and, in fact, any civilian activities related to defense.

(4) ***Rationing***

This class includes all pictures related to various things connected with rationing such as the employment of substitutes of any kind for gasoline, sugar, rubber, or other rationed commodities and should give wide scope to the imagination.

(5) ***War Production***

This class, while unavailable to many of us, will yield many interesting pictures of both industrial and agricultural activities.

(6) ***Transportation***

This class includes pictures of transportation of any kind caused by or incidental to the war effort.

(7) ***Miscellaneous***

This class includes any pictures relating to the war effort which do not fall in one of the previously mentioned classes.

The Committee reserves the right to reclassify entries in this class which they feel belong in one of the others and also to reclassify any entries which in their opinion have been entered in the wrong group.

Graphic Arts Exhibit

The theme of the Graphic Arts Exhibit is to be the war effort. All entries in this branch must have as their subject something related to the war. Patriotic poster designs will be welcome.

Entry blanks may be obtained from A.S.M.E. headquarters in New York City and the entry fee will be 50 cents per exhibitor.

Commercial Exhibit

As an added attraction to the seventh annual salon the committee desires to extend its invitation to individuals and companies to submit photographs of their various war activities. These pictures will be hung in the salon although they will not compete for the prizes. Individuals and companies will be encouraged to identify the photographs with themselves.

It is not the intention of the Committee to encourage the submission of any photographs of secret activities of any kind and all prospective entrants are hereby warned that this is a public exhibit and only pictures which could be published in a newspaper are requested. All entries will be judged on the basis of general interest, composition, and photographic excellence of technique.

Conditions of Entry

All entries must be in the name of the individual who made them. Prints in any photographic medium are eligible but no hand-colored photographs will be accepted.

The entry form properly filled in together with a fee of 50 cents from each contributor must be mailed to the Salon Committee, 29 West 39th Street, New York, N. Y., so as to arrive before midnight November 23, 1942. Remittance should be made payable to the Salon Committee, The American Society of Mechanical Engineers. All prints shall be mounted on white or very light-tinted mounts of standard (16 × 20 in.) size so as to be properly displayed with the mount in a vertical position. *Each mount must bear on the back, plainly written, its number, and title, and the class in which it is entered, as well as name and return address of contributor to correspond with entry form.*

Prints may be forwarded either by post, or by express prepaid, or delivered personally. All entries shall be packed with protection for safe transportation both ways and should arrive in New York City on or before the closing date.

The privilege of reproducing any accepted picture in connection with any publicity of the salon and/or in the magazine MECHANICAL ENGINEERING will be a condition of entry. Prints will not be sold but inquiries as to any print will be referred directly to the maker.

Due diligence will be exercised in respect to the care of the prints but the Society assumes no responsibility for loss thereof or damage thereto in transit or during the Exhibition.

All entries will be returned promptly after the close of the exhibition. The submission of entries will imply acceptance of the conditions named. The judging will be done in classes described.

A.S.M.E. Calendar

of Coming Meetings

Sept. 30–Oct. 1, 1942
Joint Meeting of A.S.M.E. Fuels and A.I.M.E. Coal Divisions
St. Louis, Mo.

October 12–14, 1942
Fall Meeting
Rochester, N. Y.

Nov. 30–Dec. 4, 1942
Annual Meeting
New York, N. Y.

(*For coming meetings of other organizations see page 34 of the advertising section of this issue*)

Last-Minute News on A.S.M.E. Fall Meeting at Rochester, October 12–14

Plant-Trip Reservations Must Be in by October 1

ARRANGEMENTS for the A.S.M.E. Fall Meeting at Rochester, N. Y., October 12–14, are well in hand and the detailed program of technical papers as published on pages 684 and 685 of the September issue remains practically unchanged with sessions on aviation, wood industries, education and training, management, production engineering, fuels, power, materials handling, and industrial instruments and regulators.

Splendid Talks Scheduled

The social side of the meeting will be restricted largely to gatherings at luncheons and to the dinner at which the honorable Humphrey Mitchell, Canadian Minister of Labor, will give the principal address. His talk will be of such importance that it will be of interest to members all over the country although it is not known as yet whether permission will be granted to publish it. So if you are attending the meeting, be sure to go to the dinner as that may be your only chance to hear this talk.

Other interesting and valuable talks will be given at the various luncheons, including that by Col. James L. Walsh, chairman of the War Production Committee of the A.S.M.E., on Tuesday, entitled "Science of Survival." Members throughout the country have been inspired by his splendid addresses and at Rochester his message will be particularly timely.

In connection with the Wood Industries sessions, a general luncheon will be held on Monday at which Dr. Nelson C. Brown of the New York State College of Forestry will speak on "The Most Important Raw Material of the Future." As materials get scarcer, the substitution of wood products becomes daily of greater interest and Dr. Brown will have an attentive audience for his talk. The third of the luncheon speakers will be Dr. Roland Woodward, Board of Regents, The University of the State of New York, whose talk on "Engineering as a Profession" will be sure to attract many.

The Women's Program

A large number of women make it their custom to attend the Fall Meetings of the Society and so the committee headed by Mrs. K. H. Hubbard, chairman, is busy with plans. The committee would be most appreciative of any advance information concerning the number of women who plan to be there. Perhaps when the men of the family send in their advance reservations they will add a special note about bringing their wives for the information of the Women's Committee whose members include Mrs. Howard Harding, Mrs. Louis B. Swift, Mrs. Stanley C. Stacy, Mrs. Lawrence Leach, Mrs. Arthur W. Schuster, Mrs. Arthur S. Hamilton, Jr., Mrs. Erwin J. McGuire, and Mrs. C. Irving Lusink.

So far the events planned for the women attending the meeting include a reception luncheon, tea at the Memorial Art Gallery, and moving pictures on Monday; luncheon at the University Club, a trip through the plant of the Clapp Baby Foods Company, and dinner with the men on Tuesday; a visit to the Eastman School of Music and luncheon at the Spring House on Wednesday.

Plant Trips

The Plant Trips Committee for the Fall Meeting at Rochester, under the chairmanship of Cleland C. Ross, has been successful in making arrangements for citizen members of the A.S.M.E. to visit several of the more important Rochester industries. However, advance registration in every case will be required and to assist members to make these trips, a special confidential circular has been prepared and will be mailed to members upon request. In order to meet the requirements imposed by the Government and management of the plants, all registrations must be made on or before October 1, either addressed to Mr. Cleland C. Ross, 82 St. Paul St., Rochester, N. Y., or to A.S.M.E. headquarters in New York City.

Hotel Reservations

One last bit of advice—while there are several good hotels available in Rochester, members are advised to make their reservations early as in these times the demand on hotel space is especially heavy. It is easier to cancel a reservation if you find that necessary than to be able to get a room at the last moment. Headquarters Hotel for the Meeting is the Sagamore.

Registration Fee for Non-Members at A.S.M.E. 1942 Fall Meeting

There will be a registration fee of $2 for nonmembers attending the 1942 A.S.M.E. Fall Meeting at Rochester, N. Y., Oct. 12–14, 1942. For nonmembers wishing to attend just one session the fee will be $1. This is in accordance with the ruling of the Standing Committee on Meetings and Program.

Members wishing to bring nonmember guests may avoid this fee by writing to the Secretary of the Soceity before October 8 asking for a guest-attendance card for the Fall Meeting. The card, upon presentation by a guest, will be accepted in lieu of the registration fee. Guests are limited to *two per member*.

If You Wish the Fall Meeting Circular—

BECAUSE of the transportation problem it is thought that few members from great distances will attend the Fall Meeting of the A.S.M.E. at Rochester and therefore the circular with certain details of the meeting is being sent only to those members within a radius of about five hundred miles.

However, so that all members may be able to obtain a copy of this announcement without delay, a small quantity of the circulars is being sent to the secretary of each Local Section outside that area. Therefore if you want additional information to that which has appeared in MECHANICAL ENGINEERING, we suggest you either get in touch with your Section Secretary or Society headquarters in New York City.

E.C.P.D. Guidance Manual

A "Manual for Committees of Engineers Interested in Engineering Education and the Engineering Profession," an aid to engineers and committees acting in an advisory capacity to high-school students considering engineering as a vocation, has recently been issued by the Engineers' Council for Professional Development. It is published with a separately bound appendix addressed to the student as a prospective engineer.

The guidance manual, referring to the previously issued booklet, "Engineering as a Career," as a supplement, offers a general procedure recommended to individuals or groups in the profession for presenting to high-school students the aims and essentials of engineering education, the aptitudes required, and the types of civilian and armed forces needing engineers. It presents material on the organization and selection of these committees representing local sections of national societies or local engineering clubs and societies, and points out the necessity of co-operation on the part of these committees with the vocational-guidance programs previously established in the secondary schools, and with other local and professional groups who are interested in the general problem of helping young people select their career or lifework.

The Committee on Student Selection and Guidance, E.C.P.D., reports that such advisory councils have been successful in Birmingham, Rochester, Cleveland, Detroit, St. Louis, Alabama, Iowa, Nebraska, and Colorado, and that interest in the engineering profession has been aroused and understanding of the field has been conveyed to some 3000 boys in New York City alone, annually.

Take an Inventory Now!

Industry Advised to Obtain Replacements as Nation's Military Man-Power Needs Increase

By Major General Lewis B. Hershey, U.S.A.

Director of Selective Service

MAN POWER is a most important strategic material of today. Every employer should make a prompt inventory, appraisal, and analysis of the man power in his own plant as he would inventory his stock pile. In order to keep production going and at the same time furnish men for the armed forces, industry should now establish an orderly replacement program.

In order to secure temporary deferments for essential men while he is training women, young men, older men, men physically handicapped or those with a high degree of dependency, the employer should know the fundamental principles in the operation of his local Selective Service Board. Certain steps should now be taken by each employer. He should know how many men on his pay roll are between the ages of 20 and 45. He should investigate the classification of every one of those men. On the basis of such an inventory he should prepare to plan ahead and train men for replacement of those who must necessarily enter the armed forces if we are to have the sort of army which can win the war.

Deferments Temporary

Deferments, granted so that employers may train women or men not liable to early induction, are temporary deferments; they cannot exceed six months and in many cases may be for only thirty, sixty, or ninety days. The Army today has to train a bomber pilot within a period of eight months to operate a very technical machine with an instrument board which puzzles an expert. Why, therefore, should industry insist that it assume that it can take two or three years to train men for industrial tasks not nearly so complicated?

The fundamental purpose of every deferment of a registrant is to allow an employer to train a replacement. Only in a few rare instances can an employer expect to have these temporary deferments continued for more than the six-months' period. These are only in cases where an abnormally long period of training is required for a replacement and the eight months needed in which a bomber pilot can be turned out now is something to remember in this connection.

Employers' Responsibility

Employers may seek the deferment of their necessary men with or without their consent.

Here is how they go about it.

On page 3 of the Selective Service Questionnaire (Form 40) which is sent to each registrant before he is classified is the following:

Instructions—If your employer believes that you are a necessary man in a necessary occupation, it is his duty to fill out Form 42A requesting your deferment. You may also attach to this page any further statement by yourself which you think the local board should consider in determining your classification. Such statement will then become a part of the questionnaire.

This is on all the questionnaires distributed during the last six months. The fact that the Selective Service System now specifically mentions the filing of Form 42A as the manufacturers' duty is a clear indication of the Selective Service System view on the responsibility of each employer in this matter.

The employer can secure Form 42A at the local board and the local board will consider the employer's request when the form is properly filled out and signed.

If such request should be denied because the man, after consideration of the claims offered for him, is not considered to be indispensable to the company's operation, and is needed more in the armed services, the local board will advise the employer of its refusal of such an occupational deferment.

The local board does this by sending to the employer, at the same time it notifies the registrant of his classification, a Form 59.

May Make Appeal

There are ten days after Form 59 is mailed by the local board to the employer in which the employer can appeal the registrant's case.

The registrant will not be ordered to report for induction during this ten-day period.

In order to take an appeal the employer simply has to sign his name to Form 59 which he has received and return it to the local board; or in case the Form 59 is not received from the local board, any written request will have full value to make such an appeal effective.

When Form 59 is returned by the employer the appeal procedure becomes automatic.

All necessary forms are available at the local board in the employer's immediate vicinity or at the office of the State Director of Selective Service.

If the local board and the appeal board deny the appeal for the occupational deferment of a key man, the employer may then bring the matter to the attention of the State Director at the State Selective Service Headquarters, with the request that the case be reopened or appealed by him to the President.

Definite Duty

A double duty rests upon the employer. He should personally know what his manpower situation is. He should not leave the job to a minor employee to decide who is necessary. The employer who delegates the task of filing a request for deferment to a clerk, the executive who does not make a complete inventory of his whole plant today, is negligent. Likewise, the employer who files requests for deferment of men who can be replaced by women, or others, is keeping reinforcements out of an Army which is battling for us all. The employer engaged in essential war production who has been required to greatly expand his plant and who then fails to request deferment for his key men is also negligent.

A good rule to follow: Don't ask deferments for any men who can be replaced by training another individual not likely to be eligible soon for service in the armed forces.

Make an inventory, request deferment for any man whose immediate going into the armed services would retard production of vital war material or other services essential to the war effort, or who is needed to maintain national health, safety, and interest.

Only when an employee is working in a critical occupation within an essential industry should a Form 42A be filed for his temporary occupational deferment.

Make Replacements

Yes, an inventory within a man's own plant is called for; also an appraisal and analysis of the man power in the community. There is many a man over 45, or a man physically handicapped, or a woman who can do that job that the 23-year-old boy is doing who took a 12-weeks' course at a learn-quick school.

There are not more than sixty million people in this country who are capable of effective productive effort. These men and women represent our total man power available to win the war. They must do everything that must be done in a total war; maintain transportation, communications, and utility systems, maintain public services, grow food for ourselves and our allies, mine the metals and produce the raw materials, fabricate and produce the amount of consumers' goods necessary to maintain even a restricted national life and the supplies, weapons, and munitions of war; also most of all they must provide the men who land on strange shores in far places, the men who carry the fight to the enemy on a multitude of far-flung frontiers. The rest of the population who mine raw materials and produce the weapons with which these men fight must be a self-disciplined team working in unity. The individual personal convenience, comfort, or pleasure, or the convenience and ordinary leisurely replacement programs of the employer will have to be given progressively less consideration as the war gets tougher and the casualty lists grow.

When we hear of the big armies we are going to raise, we must all remember that it takes at least five men or women to produce what they eat, use, fight with, and wear. With less than sixty million availables in this country, those figures are worth deep consideration.

The Members' Page[1]

A Forum for the Frank Discussion of A.S.M.E. Affairs

An Appeal to Members of the Society

IN A controversy with the Council, two problems fundamental to the Society's welfare and professional standing are involved:

Ethics

First, the Society should observe ethical standards in its own procedure.

I submitted in May, 1938, a lengthy paper as a case study of general significance on electrical rates and service in Scarsdale, N. Y. It involved the Westchester Lighting Company, a subsidiary of the Consolidated Edison Company of New York, Inc. I offered in October, 1938, to condense the paper. One committee in June, 1939, asked for about 14,000 words. Another committee in April, 1940, increased the length to about 16,000 words. The Council has now ruled the paper is too long for publication in Mechanical Engineering. No reasons have been given, however, for not publishing it in the Transactions.

Twice I have suggested publishing the body of the paper with about 10,000 words. A note could indicate that appendixes and a bibliography of about 150 references were available in mimeograph form. This suggestion has been ignored.

The original paper was a case study without names. The Society in October, 1939, requested me to use names. The Council has now ruled it cannot be published because it was not presented hypothetically.

Good sportsmen, however, do not change the rules during a game.

Publication offered in October, 1939, was postponed in order that my opponents might have ample time to prepare discussion. Further delays in a decision on presentation were then encountered. No apparent progress was made until March, 1940, when I threatened to appeal to Society membership. Not until September, 1940, was I notified the paper had been authorized for presentation in Dec., 1940. It was presented at that time.

The Committee on Publications did not rule until January, 1942, that my paper was not acceptable for publication as it could not "compete in interest and subject matter with other technical papers." The Management Division, however, had recommended its publication.

That Committee had five members of which three were as follows: One is assistant editor of *Power*, sister publication to *Electrical World*. Another is a consulting engineer on power plants who is reputed to have done considerable work for public utilities in New York State. The third member is assistant to a vice-president of the General Electric Company. One advisory member is assistant engineer for the Consolidated Edison Company. Yet this committee undertook to decide whether my paper should be published, a paper that criticizes the management policies of a large public utility in New York State.

An appeal to the Council led to review of my paper by a special committee of three. Its report against publication has been accepted by the Council. Yet one member of that committee served on a committee in April, 1940, that set the requirements for the presentation of my paper. He told me then that an appeal to the Council would be answered by the word, "No." I challenge his disinterestedness.

Space does not permit a full story of the delays and arguments encountered in connection with the presentation and the refusal to publish my paper. They merely add color to the appearance of broken faith, of lack of consistent Society policy, of dilatory methods, and of disregard of ethical considerations.

Censorship

Second, the Society should not censor professional papers.

The Council refused to publish my paper as it "deals with a definite community and a definite public-service corporation in competition." On the contrary, the Westchester Lighting Company is a monopoly under government control. Its management policies are similar to those of other public utilities, selling both electricity and manufactured gas. Its problems in Scarsdale have broad significance.

My paper shows that such low electrical rates are possible in Scarsdale for heating water and for cooking that the sale of manufactured gas could be made unprofitable. I claim the New York State Public Service Commission has been inept in its work.

I discuss also the effect of low electrical rates upon the standard of living, upon street accidents with automobiles due to poor illumination, upon increased production of goods, and upon jobs for men in a business depression. I reach the conclusion that the policies of the Westchester Lighting Company are not socially minded.

"The Aims and Objects of The American Society of Mechanical Engineers," as discussed by me in Mechanical Engineering, December, 1941, pages 914–916, are involved in the refusal to publish my paper. Supporting evidence as to censorship of professional papers is given by a letter to the editor of Mechanical Engineering, March, 1942, page 232, by Marion B. Richardson.

Space does not permit an account of the difficulties met in trying to get experts to discuss my paper. Excuses offered ranged all the way from those probably valid to admissions that discussion would lead to loss of a job or of consulting work. Yet my file has several unsolicited letters praising the excellent quality of my paper and also offering confidential assistance in any rebuttal necessary. Evidence of censorship reaching me has ranged from stories of refusals of employers to permit discussion to statements that efforts were being made to stop presentation of my paper or its publication. Yet the Council, in disregard of professional obligations, refuses publication on the plea of avoiding "controversies with individuals and corporations."

The day may come, however, when a consulting engineer for the Westchester Lighting Company will desire the Society to authorize the presentation and publication of a paper discussing gross abuse of power and public trust by some Federal commission as it affects the use of applied science in the service of humanity by his client. Such a paper will mean controversy with a Federal commission. The pressure to stop its presentation and publication probably would be great. If the Society lacks courage to insist on the prompt presentation and publication of my paper, it will not have the courage to resist Federal pressure.

Engineers have no greater obligation than to bring to all men a more abundant life in more food, more clothing, and more housing as well as those additional comforts such as low-cost electricity that in their use differentiate men from beasts. Men look to engineers for guidance and our refusal to guide them if controversy is involved is the principal reason for lack of professional recognition. Censorship of publication that prevents such guidance also prevents men from differentiating professional engineers from mechanics who are told what to do and how to do it. The Council in its fear of controversy condemns professional engineers to the position of hired mechanics.

Conclusion

I charge poor management of Society affairs, breaches of ethical considerations, and censorship of at least one professional paper. I will introduce a resolution on this charge at the Society meeting in December, 1942.

(*Signed*) Gregory M. Dexter.
Scarsdale, N. Y.
July 29, 1942

[1] Members' page for criticism of Society policies as authorized by Council. See Mechanical Engineering, December, 1936, page 856.

Among the Local Sections

Several Local Sections Hold Sessions During the Summer

Anthracite-Lehigh Valley Has Reorganization Meeting

ANTHRACITE-LEHIGH VALLEY SECTION started the ball rolling for the fall sessions with a reorganization meeting at Northampton, Pa., on June 26, 1942. Following dinner, 23 members and 14 ladies expressed their appreciation to W. Tallgren, retiring chairman, and the other officers for the excellent and successful meetings held during 1941–1942. Mr. Tallgren then introduced the new chairman, C. M. Merrick. The group approved the following schedule of meetings for the coming year: Oct., 1942, Hazleton; Jan. 1943, Reading; Mar., 1943, Wilkes-Barre or Scranton; and May, 1943, Stroudsburg. At the suggestion of Prof. P. B. Eaton, the possibility of holding a War Industry Meeting, in accordance with President Parker's proposal, was discussed. A committee was appointed by Chairman Merrick to arrange such a session sometime in September or October.

Cleveland Section Is Host for A.S.M.E. Semi-Annual Meeting

Cleveland Section was host to the members of the Society at the A.S.M.E. Semi-Annual Meeting held in Cleveland, O., June 8–10, 1942. A full account of the meeting and the splendid work done by the local members was described in full in the June, 1942, issue of MECHANICAL ENGINEERING. It can be told now how some of the local and visiting members were able to inspect some of the war factories in and near the city. In order to obtain the necessary pass from military officials, members were required to have their birth certificates, other personal identification papers, and legitimate reasons for the visits.

Detroit Section Formally Shelves Retiring Chairman Arthur Selvey

To conclude the activities of the 1941–1942 season and to initiate the 1942–1943 year, members of the retiring and incoming executive committees of Detroit Section met on June 30 at the Detroit Engineering Society. In accordance with a tradition of the Section, Arthur Selvey, retiring chairman, was formally put on the shelf, which was suitably represented by a scale model. It was covered with an assortment of objects selected to give comfort and amusement to Mr. Selvey during his period of semiretirement. Included were a miniature fireplace, a toy easy chair, a pipe, a spring-motored boat, a musical whistle, and paper towels to dry the honest sweat brought about by the arduous duties of staying on the shelf.

Members of Rochester Section Prepare Plans for Coming Year

The executive committee of Rochester Section met on June 23, 1942, to discuss plans for the 1942-1943 year. Joining in the discussion were Ernest Hartford, executive secretary of the A.S.M.E., and O. L. Angevine, representative of the Rochester Engineering Society. As a result of the discussion, the committee decided that the following items will be incorporated into the plans for the coming meeting year: (1) Meetings will be sponsored in co-operation with the Rochester Engineering Society and separately to which only members and guests shall be admitted, (2) At each executive committee meeting, every committee member will bring as his guest a member of the Section, (3) Minutes of the executive committee meeting will be available as soon after the meeting as possible, (4) A membership committee shall be set up to aid new members in becoming acquainted and adjusted, (5) A program committee will be set up, (6) A committee will be appointed to organize a student branch at the University of Rochester, (7) Efforts will be made to promote round-table discussion groups, (8) Inspection trips will be part of the year's program, and (9) A few stag parties will also be included in the program.

Luncheon Discussions Featured in June by San Francisco Section

Luncheon discussions started by San Francisco Section back in February, 1942, proved so successful that they were continued right through June. The attendance at these weekly affairs averaged between 20 and 30. The June program included plant defense, pneumatic controls, piping, and priorities.

Need of Lastics Discussed Before Southern California Section Members

Using as his subject, "Our Rubberized World—700,000 Tons Lastics and Why Needed," R. B. Springfield, consulting chemical engineer on rubber and plastics, kept 51 members and guests of Southern California Section interested for an hour and a half at the June 11 meeting held in Los Angeles. The discussion which followed showed the deep interest felt by mechanical engineers in this great problem facing their country today.

Proceedings of Second Water Conference Available

ACCORDING to an announcement received recently from the Engineers' Society of Western Pennsylvania, the Proceedings of the Second Annual Water Conference, held in November, 1941, may be obtained from the headquarters of that organization in the William Penn Hotel, Pittsburgh, Pa., at the price of $2.15. The Third Annual Water Conference is to be held there this year on November 9 and 10.

1942 Local Sections Group Conferences

Group	*City*	*Place*	*Date*	*In charge of*	*Presiding Officer*
I	Worcester	Higgins Lab. W.P.I.	Oct. 17	G. H. MacCullough	H. F. Ramm
II	New York	A.S.M.E. Headquarters	Oct. 21	G. J. Nicastro	Wm. H. Larkin
III	Rochester	Sagamore Hotel	Oct. 11	W. D. Wood	C. Schabtach
IV	Knoxville	Andrew Johnson Hotel	Oct. 24	J. F. Roberts	J. B. Jones
V	Dayton	Dayton Biltmore	Oct. 10	L. R. Bridge	A. M. Selvey
VI	St. Louis	Statler Hotel	Oct. 31	R. C. Thumser	B. G. Elliott
VII	Spokane	Davenport Hotel	Oct. 24	J. G. McGivern	H. T. Avery
VIII	Tulsa	Mayo Hotel	Oct. 28	C. O. Glasgow	R. M. Matson

TIME: 9:30 a.m. for all Conferences except for Group II which will be 5:30 p.m.

With the Student Branches

Accelerated Engineering Education Program Keeps Students in School During Summer

Many A.S.M.E. Student Branches Start Meetings in June and Attract Large Groups of Members Despite Heat and Work

WAR has caused many Student Branches of The American Society of Mechanical Engineers for the first time in the history of the Society to schedule regular meetings during the summer months. This has been brought about by the fact that many engineering colleges have decided to cut down on the amount of time required to train a mechanical engineer from four years to three by doing away with summer vacations so as to make him available sooner to industry which still lacks sufficient engineers. The Selective Service System officials have recognized this need and wisely provided for the deferment of student engineers.

Despite the heat and the extra amount of studies required of them, student members have found time to attend regular meetings of their respective Student Branches. On many campuses the Branches have arranged picnics and parties for the members during Sundays and holidays. Inspection trips to industrial plants are not being made due to war restrictions.

Ships Subject at Alabama Poly Session

Alabama Poly Branch at the July 13 meeting presented a motion picture before 60 members. The film, entitled "Building a Liberty Ship—One of the Bridge of Ships," was made at the Alabama Dry Dock and Shipbuilding Co., in Mobile, Ala., and covered the subject from the construction of the ways to the launching and fitting out of a C-2 type of cargo carrier. The showing was accompanied by a lecture given by J. B. Knowlton, assistant state supervisor of trade and industrial education of Alabama.

Case Boys With Girls at Beach Party

Case Branch members and their girl friends attended the beach party held on July 24 at the Mentor Harbor Yacht Club. High lights of the evening were swimming in Lake Erie, a weiner roast, and a novel "battle of the sexes" in which the opposite sexes vied to see which group could first assemble pipe fittings to spell out the letters "A.S.M.E."

Catholic University Meets July 16

Catholic University Branch held the first meeting of the new school year on July 16. The meeting was in the form of a "get-acquainted" program and featured talks by Prof. C. O. G. Wittig, honorary chairman, who talked of coming events; Prof. M. E. Weschler, past honorary chairman, who spoke of the history of the organization; Dean A. J. Scullen, who discussed the accelerated program; and Rev. Dr. Edgar Lang, dean of men, who urged members to attend all meetings of the Branch and to boost the organization.

56 Attend Cooper Union Session

Robert L. Sackett, dean-emeritus of the school of engineering at The Pennsylvania State College and assistant secretary of the A.S.M.E., was the speaker at the opening session of Cooper Union Branch held on Aug. 17. Speaking on the subject, "The Influence of the War on Mechanical Engineering," Dean Sackett's talk dealt with invention, design, tools, and management.

George Washington Engineers' Mixer

George Washington Branch of the A.S.M.E. in conjunction with the local groups of the A.I.E.E. and A.S.C.E. held an "engineers' mixer" meeting to which all students in the school were invited. After the introduction of faculty members, the "mixer" was adjourned one hour to enable each student group to hold a meeting. Following the meetings, all returned to enjoy themselves at the "mixer" session.

MEMBERS OF A.S.M.E. STUDENT BRANCH (MECHANICAL DIVISION) AT NEW YORK UNIVERSITY, 1941-1942

Student Branch Secretaries

Please Note!

REPORTS of meetings and inspection trips must be received at Society Headquarters on or before the sixth of the month in order to appear in next month's issue of Mechanical Engineering. For example, all copy received up to Oct. 6 will be in the November issue, etc.

PHOTOGRAPHS of student-member groups are always welcome for use in Mechanical Engineering. Prints should be preferably glossy and of good contrast. However, send in everything you have and the editorial department will use those it can reproduce.

PUBLICITY is always good for the branch. Clippings from school and local newspapers should be sent in with your reports.

War Program at Iowa State

Prof. R. E. Roudebush, honorary chairman of Iowa State Branch, was the first speaker at the July 8 meeting. He read and explained a letter from national headquarters regarding the operation of the Branch under the wartime accelerated program and the status of seniors who enter the armed forces upon graduation. He was followed by Prof. David L. Arm, new head of the mechanical-engineering department, who among several things stated that engineering curriculums would continue because of the great need for engineering graduates both in industry and the military services.

Newark Shows Aircraft Pictures

Newark Branch held a meeting on Aug. 6, at which motion pictures on the manufacture of aircraft engines, and on combustion and detonation in internal-combustion engines were shown and described by Kenneth Kasschau, assistant chief project engineer of the Wright Aeronautical Corporation.

Northeastern Branch Members Meet

The first meeting of the term was held by Northeastern Branch on July 7 and was for the purpose of electing new officers. Speakers at subsequent meetings included Howard Rowell, James Dicklow, and Joseph De Sanctis, who described some of their work as co-operative students.

Notre Dame Starts Early in June

Notre Dame Branch started rolling early by holding its first meeting on June 10. Plans were discussed for athletic events to be held during the summer. Following the serving of refreshments, a short movie on the maintenance of propellers was shown.

First Maryland Meeting Draws 125

The June 24 meeting of MARYLAND BRANCH, the first held under the new three-semester wartime program, attracted 125 students. Dr. John E. Younger, chairman of the mechanical-engineering department and secretary of the A.S.M.E. Aviation Division, discussed the advantages of membership for a student. The talk was followed by a film showing the manufacture of the B-26 bomber airplane.

Social Life at Michigan State

On July 23, members of MICHIGAN STATE BRANCH engaged in a ball game, followed by a canoe trip down the Red Cedar River to Professor Price's gardens where all took part in a steak roast.

Mississippi Holds Evening Meetings

The June 24 meeting of MISSISSIPPI STATE BRANCH was opened by Chairman E. W. Pettis. After the cigars were passed, the members started the business part of the program. The speaker was Prof. O. D. M. Varnado, who spoke of the value of joining an organization such as the A.S.M.E.

Missouri Mines Gets Going Too

The main topic of discussion at the June 25 meeting of MISSOURI SCHOOL OF MINES BRANCH was the advantages inherent to joining the A.S.M.E. A motion was made and passed that a softball game be scheduled with the local chapter of the A.S.C.E.

A.S.M.E. STUDENT BRANCH MEMBERS AT STANFORD UNIVERSITY, APRIL 22, 1942

First Meeting at Ohio State

The first meeting of the term was held by OHIO STATE BRANCH on June 26. New members were acquainted with the advantages of membership in the organization. More than 125 members were present.

STUDENT MEMBERS OF THE A.S.M.E. AND TWO FACULTY MEMBERS OF THE POLYTECHNIC INSTITUTE OF BROOKLYN

(At the annual Easter Student Meeting of Group II of the A.S.M.E., Villanova College as Host.)

SENIOR MEMBERS OF A.S.M.E. STUDENT BRANCH AT MARQUETTE UNIVERSITY

(This picture was taken on Sunday evening, April 19, 1942, of the entire senior membership at Marquette—all of whom were A.S.M.E. student members. Nine of the 36 have been commissioned ensigns in the United States Naval Reserve and left immediately for active engineering duty with the Navy. Because of the War, the seniors were graduated 42 days ahead of schedule as the result of hours of extra work by both students and faculty.)

Penn State Holds Dinner Meeting

PENN STATE BRANCH held a dinner meeting on July 6 in conjunction with the A.S.C.E. student chapter. The feature of the evening was a paper on the Smith-Putnam experimental wind turbine given by George A. Jessup, chief engineer of S. Morgan Smith Co., York, Pa. This turbine, 1000 kw in capacity, is located in a 120-ft-high tower on Grandpa's Knob in the Green Mountains of Vermont.

Students Talk Before Princeton

The first meeting of PRINCETON BRANCH was held on Aug. 10. After the election of officers, C. L. Tutt spoke on the flame-hardening process for steel and cast-iron gears, and N. J. Sollenberger gave a report on alternative steels for production under wartime priorities.

Purdue Shows Lubrication Movie

More than 150 members and guests were present at the first meeting held by PURDUE BRANCH on June 24. After introductory remarks by Chairman Sam Lloyd, a motion picture was shown which described by ingenious diagrams the reasons for lubrication and the evaluation of different types of lubricants.

100 Per Cent Rose Poly Membership

At the first meeting held on July 6 by ROSE POLY BRANCH, all the eligible students (43 in number) joined and paid their dues. This is a record of which any Student Branch may well be proud.

Committees Appointed at Tennessee

TENNESSEE BRANCH held a meeting on July 9 at which the following committees were appointed: Publicity Committee—J. G. Liker, R. B. Walker, and T. H. Townsend, and Program Committee—L. F. Chandler, John Dobbs, and William Emory. Mr. Chandler

(*Continued on page 762*)

A.S.M.E. Student Group Meetings, 1942

GROUP I—NEW ENGLAND STUDENT MEETING, BURLINGTON, VT., APRIL 24–25, 1942

Attendance: 80 Papers presented: 10

Prize	Recipient	Title of Paper	College
First	Franklyn Gokey	"An Investigation of the Electric Strain Gage and its Relation to the Field of Mechanical Engineering"	Rensselaer
Second	Harvey E. Schock, Jr.	"Spot Welding"	Cornell
Third	Henry Elksnin	"Rotor Broaches"	Northeastern
Old Guard	Philip French	"Method of Measuring Transformation Temperatures of Metals"	New Hampshire
Fifth	Walter E. Stanger	"Gas Turbines"	Tufts

GROUP II—EASTERN STUDENT MEETING, VILLANOVA, PA., APRIL 20, 1942

Attendance: 303 Papers presented: 14

Prize	Recipient	Title of Paper	College
First	Eric P. Bloomfield	"The Distribution of Power in the Cylinders of an Automobile Engine"	Poly. Inst. of Brooklyn
Second	Jack R. Dunn	"Opposed-Piston Internal-Combustion Engines"	Lafayette
Third	Sidney A. Broughton	"Compressibility of Air at Acoustic Speeds"	Univ. of Pennsylvania
Old Guard	Robert L. Van De Mark	"The Design of an Automatic Record Changer"	Swarthmore
Fifth	John H. Dudley	"Statistical Methods for Quality and Control"	Lehigh
Hon. Mention	George R. Fusner	"The High-Velocity Thermocouple"	Newark College of Engrg.
Hon. Mention	Gerald F. Robinson	"Naval Gun-Fire Control"	New York University

GROUP III—ALLEGHENIES STUDENT MEETING, STATE COLLEGE, PA., APRIL 10–11, 1942

Attendance: 165 Papers presented: 9

Prize	Recipient	Title of Paper	College
First	Paul W. Recknagel	"How Smooth Should a Bearing Surface Be?"	Ohio State University
Second	Julius Ritter	"Standard Welding Symbols and Their Use"	George Washington Univ.
Third	William A. Weinkamer	"The Air-Cooled Engine vs. The Liquid-Cooled Engine in Military Aircraft"	Case School of Applied Science
Old Guard	John K. Burkley	"Principle and Applications of a Pneumatic Clutch"	Univ. of Akron
Fifth	Wallace M. Beckstrom	"Modern Pressure Measurements"	Carnegie Inst. of Tech.

GROUP IV—SOUTHERN STUDENT MEETING, KNOXVILLE, TENN., MARCH 29–31, 1942

Attendance: 169 Papers presented: 11

Prize	Recipient	Title of Paper	College
First	John E. Ginter	"Practical Pin Method of Measuring Spur Gears"	Virginia Poly. Inst.
Second	Edward A. Neu, Jr.	"Designing an All-Purpose Projector"	Duke University
Third	Lawrence F. Chandler	"Electrophotographic Ballistometry"	Univ. of Tennessee
Old Guard	George Griffin	"Developments of the Coal-Dust Diesel"	Vanderbilt Univ.
Fifth	D. E. Mapother	"Independent Suspension"	Univ. of Louisville

GROUP V—MIDWEST STUDENT MEETING, NOTRE DAME, IND., APRIL 20–21, 1942

Attendance: 148 Papers presented: 15

Prize	Recipient	Title of Paper	College
First	Jorma O. Sarto	"A Stereoscopic Method for X-Ray Inspection"	Michigan State College
Second	Edward H. Nesbitt	"Feedback Speed Control Drive"	Univ. of Detroit
Third	Leonard V. Sloma	"Vibration Isolation With Cork"	Northwestern
Old Guard	John H. Baker	"A Justifying Typewriter"	Iowa State College
Fifth	George F. Topinka	"Some Aspect of Wing Vibration and Flutter"	Purdue University

GROUP VI—NORTH CENTRAL STUDENT MEETING, ST. LOUIS, MO., APRIL 17–18, 1942

Attendance: 151 Papers presented: 14

Prize	Recipient	Title of Paper	College
First	Arthur D. McGovern	"The Revealing Shimmy"	Kansas State College
Second	Wilber J. Jankowitz	"A Photoelastic Study of the Stress Distribution in Riveted Aircraft Joints"	Washington University
Third	William H. Fitzsimmons	"Weighing Small Pressure Differences"	Kansas State College
Old Guard	Henry H. Schmall	"Some Theoretical Applications to Cooling-Tower Design"	Univ. of Nebraska
Fifth	William H. Brownsberger	"High Man Takes All"	Univ. of Missouri

GROUP VII—SOUTHWEST STUDENT MEETING, HOUSTON, TEX., MARCH 23–24, 1942

Attendance: 260 Papers presented: 20

Prize	Recipient	Title of Paper	College
First	Vaughan Connor	"The University of Texas Polyphase Quick-Freezing Machine"	Univ. of Texas
Second	Robert C. Borman	"Progress in Instrument Flying and Landing"	Univ. of Arkansas
Third	John Mooney	"The Effect of Water Velocity Upon Heat Output of Convectors"	Texas Tech. College
Fourth	L. L. Blake, Jr.	"Metal Spraying"	Rice Institute
Fifth	William Rudolph	"Arc Welding in Shipbuilding"	Tulane University
Old Guard	George H. Gwin	"The Engineer's Part in Postwar Reconstruction"	A.&M. College of Texas
Seventh	John L. Martinez	"Fundamentals of Airfoil Design"	Tulane University
Eighth	John McEwin	"The Calibration of the Leftwich-Wilson Automatic Vacuum Pump"	Texas Tech. College

(*Continued on page 762*)

A.S.M.E. Student Group Meetings, 1942

(*Continued from page 761*)

GROUP VIII—PACIFIC NORTHWEST STUDENT MEETING, VANCOUVER, B. C., CANADA, APRIL 27–29, 1942

Attendance: 64 Papers presented: 10

Prize	*Recipient*	*Title of Paper*	*College*
First	FRANK D. REYNOLDS	"Design and Construction of a Magneto for Miniature Gasoline Engines"	Univ. of Washington
Second	CLARK DEHAVEN	"Improvements in Farm-Tractor Design"	Oregon State College
Third	GILBERT H. BECKWITH	"Firecracker Welding"	Univ. of Washington
Old Guard	PETER KOCH	"United We Stand"	Montana State College
Fifth	SIDNEY C. ROONEY	"Chemical Recovery Systems for Kraft Mills"	Univ. of British Columbia

GROUP IX—ROCKY MOUNTAIN STUDENT MEETING, LARAMIE, WYO., APRIL 9–10, 1942

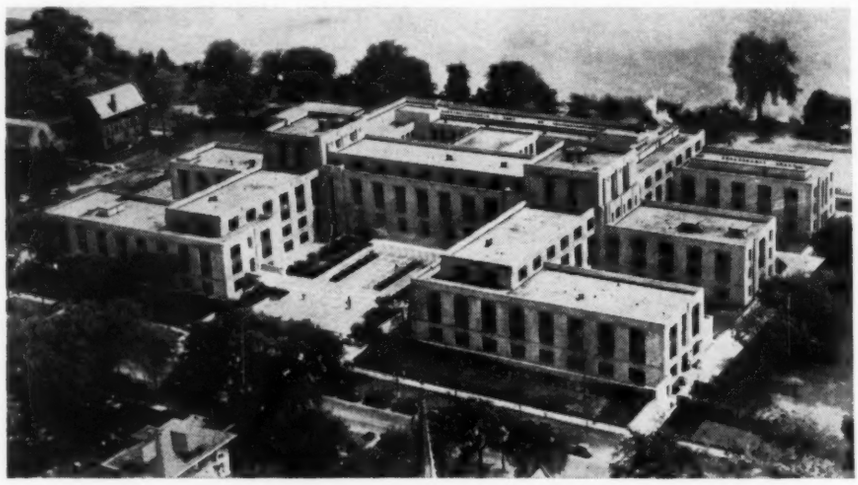
Attendance: 93 Papers presented: 8

Prize	*Recipient*	*Title of Paper*	*College*
First	ROBERT F. HARTMAN	"Synthetic Rubber Vs. War"	Colorado School of Mines
Second	LEEROY LINN	"Modern Trends in Marine Power Plants"	Univ. of New Mexico
Third	RICHARD W. KELLOGG	"Trends in the Selection of Power Plants for High-Speed Pursuit Planes"	Univ. of Colorado
Old Guard	STEPHEN S. KOCH	"Photography in Airplane Production"	Univ. of New Mexico
Fifth	ERHARD D. NIELSEN	"Moulding Plastics and Mould Design"	Colorado State College

GROUP X—PACIFIC SOUTHWEST STUDENT MEETING, BERKELEY, CALIF., MARCH 27–28, 1942

Attendance: 93 Papers presented: 9

Prize	*Recipient*	*Title of Paper*	*College*
First	WESLEY H. HILLENDAHL	"The Design and Calibration of a Thermal Anemometer"	Stanford University
Second	LAWRENCE W. SMITH	"A Test of a New Design of a Rotary Gear Pump"	California Inst. of Tech.
Third	GORDON K. WOODS	"A Direct-Reading Horsepower-Indicating Device"	California Inst. of Tech.
Old Guard	B. W. DEPEW	"Fire Extinguishing With High-Pressure Spray"	Univ. of Santa Clara
Fifth	BERNARD J. BANNON	"Induction Heat-Treating"	Univ. of Santa Clara



THE TECHNOLOGICAL INSTITUTE OF NORTHWESTERN UNIVERSITY

(Dedicatory ceremonies were held on June 15 and 16 at the formal opening of the new $5,000,000 building and were attended by more than a thousand representatives of industrial firms, scientific groups, and educational institutions. The A.S.M.E. was represented upon this occasion by James D. Cunningham, past vice-president of the Society.)

(*Continued from page 760*)

started the program off by giving a talk entitled, "Engineers in Preparation for the Coming Peace."

Texas A.&M. Audience of 101

An evening meeting held by TEXAS A.&M. BRANCH had an audience of 101 members and guests. The program consisted of a film, "The World's Largest Electrical Workshop," showing in an interesting manner the large General Electric Company laboratories and mass-production plants.

Tufts Promotes Co-Operation Plan

TUFTS BRANCH members decided on June 4 at the first meeting of the term to promote better co-operation and friendship between the members of the various engineering organizations on the campus. As a result a number of intersociety softball games and two joint meetings were sponsored.

First V.P.I. Meeting Has 150

On June 25, the V.P.I. BRANCH held its first meeting of the term. Freshmen were guests in order to acquaint them with the A.S.M.E. and its functions. The total number, including members, was approximately 150. At the Aug. 24 session, the attendance exceeded 175.

Washington's First Session July 8

Robert Brown, chairman of WASHINGTON UNIVERSITY BRANCH, opened the first meeting of the term on July 8 by introducing Professor Tucker, who explained the purposes and advantages of joining the A.S.M.E. Every member was requested to submit his name for service on one or more committees.

(*A.S.M.E. News continued on page 764*)

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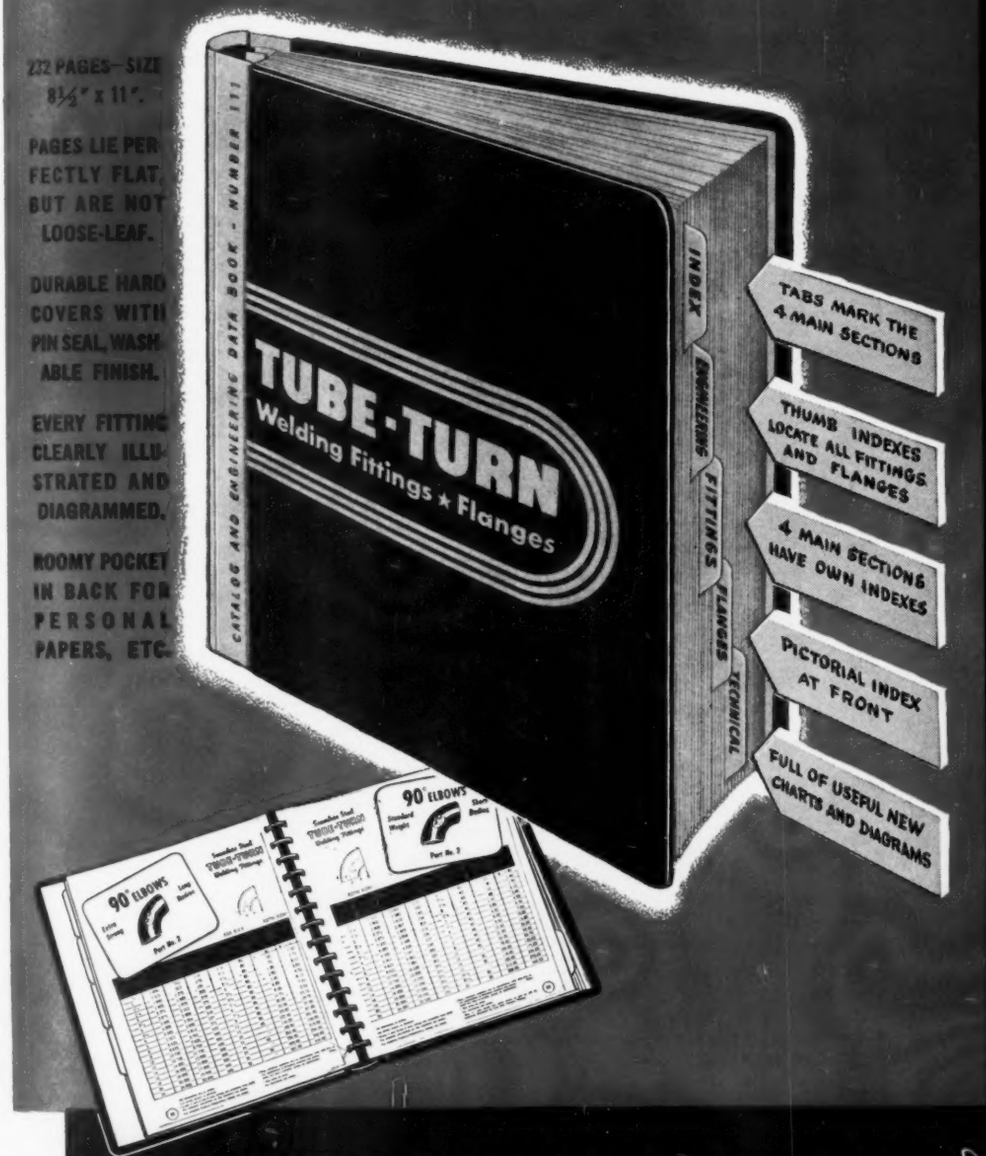

TABS MARK THE 4 MAIN SECTIONS

THUMB INDEXES LOCATE ALL FITTINGS AND FLANGES

4 MAIN SECTIONS HAVE OWN INDEXES

PICTORIAL INDEX AT FRONT

FULL OF USEFUL NEW CHARTS AND DIAGRAMS

- Designation of Wall Thickness
- Pressure Temperature Ratings
- *Allowable "S" Valve Tables
- *Flexibility of Pipe Lines and Charts
- *Tube-Turn Method of Expansion Loops
- Typical Expansion Loops (pictures)
- *Expansion Loop Chart and how Used
- Cold Springing
- *The Flow of Fluids
- Viscosity Conversion Chart
- Pressure Loss Chart
- *Flow of Flashing Mixtures
- *Steam Flow Through Pipes
- Properties of Pipe
- Dimension Tolerances for Welding Fittings and Flanges
- Pressure Ratings for Flanges
- Physical and Chemical Requirements for Flanges
- Pump Capacities
- Hardness Conversion Table
- Gas Density
- Table for Gauging Horizontal and Cylindrical Tanks
- Conversion Tables
- List of Welding Symbols, Material Color Code, Labeling Abbreviations

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Engineering Societies Personnel Service, Inc.,

These items are from information furnished by the Engineering Societies Personnel Service, Inc., which is under the joint management of the national societies of Civil, Electrical, Mechanical, and Mining and Metallurgical Engineers. This Service is available to members and is operated on a co-operative, nonprofit basis. In applying for positions advertised by the Service, the applicant agrees, if actually placed in a position through the Service as a result of an advertisement, to pay a placement fee in accordance with the rates as listed by the Service. These rates have been established in order to maintain an efficient, nonprofit personnel service and are available upon request. This also applies to registrants whose notices are placed in these columns. All replies should be addressed to the key numbers indicated and mailed to the New York office. A weekly bulletin of engineering positions open is available to members of the co-operating societies at a subscription of $3 per quarter or $10 per annum, payable in advance.

New York	Boston, Mass.	Chicago	Detroit	San Francisco
29 W. 39th St.	4 Park St.	211 West Wacker Drive	100 Farnsworth Ave.	57 Post Street

MEN AVAILABLE

INDUSTRIAL ENGINEER, electrical graduate, with 30 years' experience in electric-machinery manufacture; cost, labor, expense control; knowledge of tools, processes; labor relations, materials. Draft-exempt, immediately available, any location. Full time or consultant. Me-771.

DEVELOPMENT ENGINEER, general process engineering and equipment, plant design and construction; 24 years' experience. At present head of development laboratory of large firm. Location desired, New York City or lower Connecticut. Me-772.

MECHANICAL ENGINEER, American, age 49, excellent health, married. Have wide and thorough experience in industry as chief and plant engineer, practical shop and drafting experience. Versatile and dependable; open for immediate employment. Me-773.

TECHNICAL GRADUATE MECHANICAL AND ELECTRICAL ENGINEER. Thirty-four years' experience—reports—engineering design and construction with prominent consulting engineers in responsible charge of work. All phases of steam and power generating facilities. Me-774.

POSITIONS AVAILABLE

MECHANICAL ENGINEER, 40–55, for research and development and machine design for special machine-development laboratory. Knowledge of textile machinery would be beneficial. $3000–$4000 year. Permanent. New Jersey. W-1054.

ENGINEERS. (*a*) Industrial engineer, graduate, with from 5 to 10 years' experience in actual industrial engineering work since graduation. Duties will involve responsibility for time and motion-study job evaluations, wage scales, plant layouts, safety and first aid, and various industrial-engineering investigations relative to the economies of present and proposed layouts. $5000 year. (*b*) Engineer with considerable amount of practical experience in lens grinding. Should be capable of assisting in obtaining proper equipment, method of installing, training of operators, and operations of lens-grinding department. Prefer experience checking, mounting lenses. $3500–$5000 year. New York State. W-1059.

METHODS ENGINEER. Will consider applicant with advanced time-study experience in machine-shop practice. Must know jigs, tools, and fixtures. Plant 50–75 miles out of New York City in New Jersey. $5000–$6000 year. W-1060.

INSTRUCTORS to teach engineering drawing and descriptive geometry. Prefer young engineering graduates, but will consider older men with proper qualifications. Salary, $1800–$3000 for 9 months' service, depending upon qualifications. Illinois. W-1076-C.

MECHANICAL ENGINEER, young, to take over some of new design and development work. Should have some experience in designing mechanical units in their entirety, and be familiar with sheet-metal and welded-steel construction, and possibly have experience with hydraulic systems. Permanent. Salary open. Maryland. W-1081.

PRODUCTION ENGINEER to assist plant superintendent. Must be able to devise speed-up methods in tooling and machining. Permanent. New Jersey. W-1088.

MACHINERY INSPECTOR familiar with steam and hydro turbines, Diesel engines, miscellaneous mechanical and electrical power apparatus. Traveling required. Experience with one of large manufacturers as erector or service engineer desirable. $2700–$3000 year. Eastern U. S. W-1093.

INDUSTRIAL ENGINEER with statistical and accounting experience. Should be familiar with time study and modern plant-production management methods. Headquarters New York, N. Y. Permanent. W-1106.

GRADUATE MECHANICAL ENGINEERS, 30–60. Must be executive type with background in manufacturing field and at least 10 years' experience. Will direct about 200 men in coordination of production scheduling and control of manufacturing. Able to develop reports. $3000–$3800 year. Ohio. W-1118.

WRITER, preferably graduate mechanical engineer, with definite experience as a writer, possibly with trade publication. Will write specifications and manuals on wide range of technical subjects, mostly mechanical with some electrical. Must have versatile engineering background and be able and willing to do professional mechanical drafting, research, and participate in solution of wide variety of mechanical-engineering problems. Must be reasonably draft-exempt. $3600–$5000 year. New York, N. Y. W-1126.

MECHANICAL ENGINEER, 33–40, graduate, with design experience and possibly some production experience. Electrical background beneficial but not necessary. Should be good executive type and know how to allocate responsibility. Married and draft-deferred. Salary open. Pennsylvania. W-1133.

PLANT SUPERINTENDENT, 30–40, graduate mechanical engineer preferred. Plant has 200 employees and is in woodworking field, although this experience, though desired, is not necessary. Must be able to direct skilled labor; knowledge of modern methods; able to keep plant output up. About $4000 year. Permanent. New Jersey. W-1137.

PACKAGING PLANT ENGINEER, full time, for old successful concern planning modernization and enlargement. Need guidance in obtaining additional, and rearranging present, equipment. Man familiar with commercial baking mixers, dehydrators, filling devices, etc. required. Pennsylvania. W-1142.

PLANT ENGINEERS. (*a*) Engineer who can supervise and be held responsible for activities of maintenance department covering millwrights, pipers, sheet-metal men, carpenters, painters, and miscellaneous welders, etc. Must also supervise electrical department, janitors, and powerhouse activities. New England. (*b*) Engineer with similar experience, but capable of somewhat wider responsibilities in plant employing 25,000. Kansas. Prefer applicant from western territory. (*c*) Electrical engineer who can handle technical electrical problems properly and also supervise operation of electrical work in Kansas through competent electrical foreman. Salaries open. W-1150.

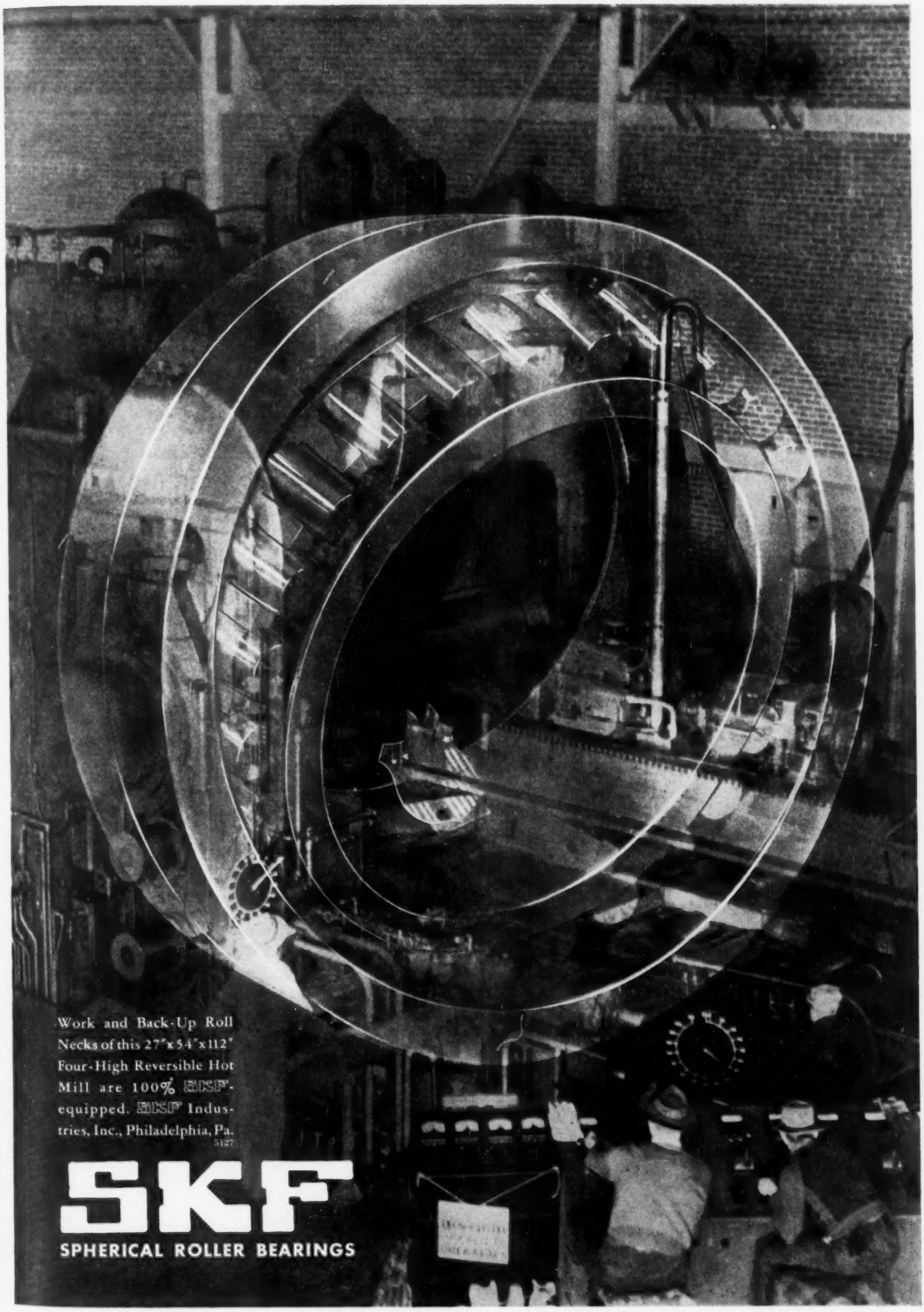
TIME-STUDY MEN, 2, preferably under 35, with experience in time-study field. At least one of applicants should be quite familiar

(*A.S.M.E. News continued on page 766*)

[1] All men listed hold some form of A.S.M.E. membership.

N.I.A.A. to Issue Industrial Training Manual

THE National Industrial Advertisers Association is undertaking the collection and indexing of all available training material, including booklets, slide films, movies, instruction manuals, and charts to be used in a "Guide to Industrial Training Material," for distribution on request to government bureaus, through government direction, or to individual industrial firms, or to "training within industry" groups. Institutions having material to contribute to the manual should communicate with Lansing Moore, Industrial Training Material Committee, Industrial Marketers of Detroit, 900 Donovan Bldg., Detroit, Mich.


Work and Back-Up Roll Necks of this 27"x54"x112" Four-High Reversible Hot Mill are 100% SKF-equipped. SKF Industries, Inc., Philadelphia, Pa.
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SPHERICAL ROLLER BEARINGS

with machine-tool operations. Should be draft-exempt. About $4000 year. Headquarters, New York, N. Y. W-1155.

GRADUATE MECHANICAL ENGINEER, to 45 years of age, for foreign service. Should have clear knowledge of small moving parts such as instruments, complicated office machinery, etc. Will be required to maintain and instruct others regarding equipment. U. S. citizen. $7000–$8000 plus insurance and transportation abroad. Give draft status. W-1160.

GRADUATE MECHANICAL ENGINEER, must be mechanical engineer in broadest sense of that term—one who can recognize, quantitatively analyze, and solve complex problems in pure mechanics. Must be skilled analyst, experienced in wide variety of mechanical-engineering problems. Permanent. At present will be definitely identified with war effort and later will participate in similar work on peacetime products. Salary, $3600–$5000 a year. New York, N. Y. W-1165.

DIESEL PLANT ENGINEER for operation and maintenance of utility power plant. Man with extensive Diesel maintenance and installation experience preferred. Will also consider technical graduates with maintenance and operating experience. Prefer men experienced in Diesel utility-plant operation. Spanish desirable but not essential to start. Apply by letter giving full past experience and salary earned in each position; also Selective Service classification and status. $3600–$4200 a year. South America. W-1174.

INDUSTRIAL ENGINEER familiar with motion, time study, and rate setting to supervise established method and time-study department. Company has 900 employees engaged in foundry, machine-shop, fabricating, and forge-shop production and has installed the Norris Unit System. Should have all-around qualifications to supervise work and take full responsibility. Must have personality and ability to sell ideas to workmen and to meet shop supervision on equal basis. About $4800–$6000 year depending applicant. East. W-1182.

INSTRUCTORS who have graduated in mechanical engineering from reputable school. Past experience in teaching is not necessarily a requirement but is desirable. Instructors are needed for Naval Diesel Training school. $2600–$3120 year. Middle West. W-1183.

DESIGNERS AND DRAFTSMEN with some experience in heavy plate work, some welding design, or structural. A knowledge of tractor construction desirable. Permanent. Salary open. Ohio. W-1198.

DESIGN ENGINEER, mechanical, with several years' experience in design and preferably operation of high-speed rotating equipment. Familiarity with basic machine elements and their application as well as grounding in fundamentals of analysis essential. Thorough knowledge of engineering materials an asset. Must have appreciation of principles of thermodynamics, mechanics of materials, and dynamics. Duties will be origination and development of over-all and detail mechanical design of variety of rotating equipment. $3300–$4200 year. Permanent. Pennsylvania. W-1200.

Candidates for Membership and Transfer in the A.S.M.E.

THE application of each of the candidates listed below is to be voted on after October 26, 1942, provided no objection thereto is made before that date, and provided satisfactory replies have been received from the required number of references. Any member who has either comments or objections should write to the secretary of The American Society of Mechanical Engineers immediately.

KEY TO ABBREVIATIONS

Re = Re-election; Rt = Reinstatement; Rt & T = Reinstatement and Transfer to Member.

NEW APPLICATIONS

For Member, Associate, or Junior

ALICO, JOHN, Las Vegas, Nevada
ALLEN, ROBT. L., Atlanta, Ga.
ALLER, WILLIS F., Dayton, Ohio
ANSEL, HARRY R., Washington, D. C. (Rt & T)
BASS, GEO. E., Bridgeton, N. J.
BAYBUTT, JOHN W., Rochester, N. Y. (Rt)
BECKWITH, WARD, Norvelt, Pa. (Rt & T)
BELINKINE, JULIUS A., Brooklyn, N. Y.
BLACKBURN, JAS. E., JR., Upper Montclair, N. J.
BOKUM, WM. H., Old Greenwich, Conn.
BROWN, RICHARD A., Eureka, Calif.
BRYAN, HERBERT G., St. Louis, Mo.
CRANKSHAW, EDWIN, Cleveland, Ohio
DARNELL, J. R., Naperville, Ill. (Rt)
DE WITT, CHAUNCEY O., Bergenfield, N. J. (Rt & T)
DIXON, JOHN J., Pittsburgh, Pa.
DOWNING, FRED T., Diablo Heights, C. Z.
DU, DARFOON, Dansville, N. Y.
GAUCHER, JULES, Brownsburg, Que., Can.
GERMER, FRED W., New York, N. Y.
HEALY, WM. J., Morrisville, Pa. (Rt & T)
HENRY, JACOB S., New York, N. Y.
JAMES, WM. J., Berkeley, Calif.
JANSEN, CARL, Chicago, Ill.
KUMMER, FRED S., New York, N. Y.
LEE, ROWLAND C., Los Angeles, Calif. (Re)
LONDON, MAURICE, Brooklyn, N. Y.
MARSH, FRED G., Pittsburg, Calif.
MARSHALL, MICHAEL N., Brooklyn, N. Y.
MILLER, WESLEY A., Pittsburgh, Pa.
MONTAGUE, EDW., Chicago, Ill.
MORGAN, GEO. E., Knoxville, Tenn.
MORO-LIN, JOS. J., Bronx, N. Y.
MURPHY, TIMOTHY H., Schenectady, N. Y.
PORSKIEVIES, A. J., Detroit, Mich.
RELYEA, JOHN D. (MAJ.), Toronto, Ont., Can.
RIESING, ELLWOOD F., Detroit, Mich.
ROSE, JOS. G., 3rd, Dallas, Tex.
SARGENT, BEN S., Rock Island, Ill.
SEAGO, ROBT. M., New Orleans, La.
SHOEMAKER, ROBT. E., Charleston, W. Va.
SMYTH, DAVID V., Waterbury, Conn.
STEGEMAN, H. J., Bridgeport, Conn.
TATE, MATLOCK K., Lima, Ohio
THOMPSON, DONALD, Spring Hill, W. Va. (Rt & T)
THORRY, JOHN, St. Albans, N. Y.
WALKER, NELSON C., Baltimore, Md.
WALSH, WM. E., Chicago, Ill. (Rt)
WEISS, HERBERT K., Camp Davis, N. C.
WELDY, GEO. H., Tamaqua, Pa.
WEST, WOODROW W., Narberth, Pa.

CHANGE OF GRADING

Transfers from Junior

BENSINGER, SAML., Washington, D. C.
ESKIN, SAML. G., Pittsburgh, Pa.
NAYLOR, FRANKLIN L., JR., Glendale, Calif.
MCCONAGHY, JAS. W., Phillipsburg, N. J.
PELLER, LEONARD, Philadelphia, Pa.
PETERSON, VERNON A., Denver, Colo.
SHELTON, N. THOS., New York, N. Y.

A.S.M.E. Transactions for September, 1942

THE September, 1942, issue of the Transactions of the A.S.M.E., which is the *Journal of Applied Mechanics*, contains:

TECHNICAL PAPERS

Torsional and Flexural Buckling of Bars of Thin-Walled Open Section Under Compressive and Bending Loads, J. N. Goodier

Distribution of Stress in Built-In Beams of Narrow Rectangular Cross Section, F. B. Hildebrand and Eric Reissner

Buckling of Semimonocoque Structures Under Compression, T. K. Wang

Graphical Analysis of Impact of Elastic Bars, K. J. DeJuhasz

Some Dynamic Properties of Rubber, C. O. Harris

Two Problems of Thermal Stress in the Infinite Solid, N. O. Myklestad

DISCUSSION

On previously published papers by A. Hrennikoff; D. J. McAdam, Jr.; and M. A. Sadowsky

BOOK REVIEWS

Necrology

THE deaths of the following members have recently been reported to headquarters:

BELKNAP, ETHELBERT, August 21, 1942
DANFORTH, RAYMOND H., August 30, 1942
FOSTER, CHARLES C., May 28, 1942
GAVETT, JOSEPH W., August 28, 1942
GORDON, REA MILTON, January 31, 1942
GRIFFIN, W. A., January, 1942
GURLEY, LEON R., August 26, 1942
KNOX, THOMAS E., August 7, 1942
MAIN, CHARLES R., August 22, 1942
SCUDDER, HEWLETT, July 31, 1942
SMITH, ALBERT W., August 16, 1942
STRUBEN, STEPHAN J., July 30, 1942
TRENT, WALTER E., January 19, 1942
TYSON, J. S. Y., June 26, 1942